

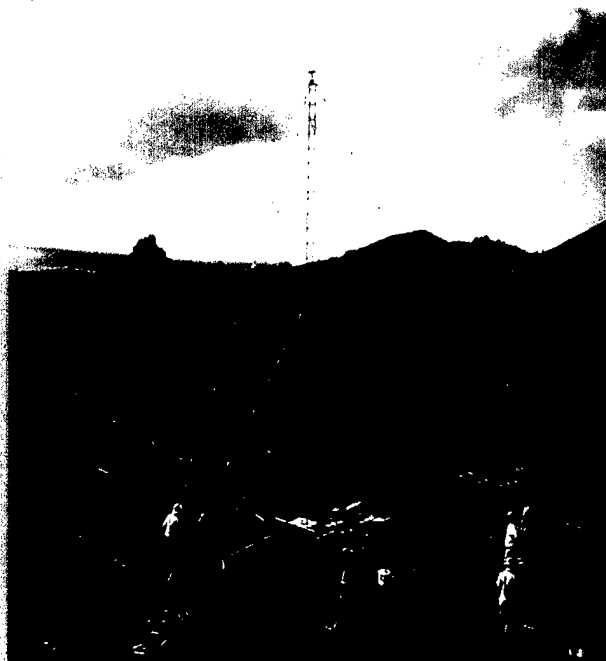
REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
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1. REPORT DATE (DD-MM-YYYY) xx-07-1999		2. REPORT TYPE Technical Publication (Report)		3. DATES COVERED (From - To) 01-08-1998 to 01-07-1999	
4. TITLE AND SUBTITLE Space Environment Network Display (SEND) Limited Military Utility Assessment FINAL REPORT				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Dr Robert Alvarez ; Author				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Detachment 1, AF Operational Test & Evaluation Center 8500 Gibson Blvd Southeast Kirtland AFB, NM 87117-5558				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Force Space Battlelab 730 Irwin Ave, Ste 83 Schriever AFB, CO 80912-7383				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT A Approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT The US Air Force Space Battlelab designated the Detachment 1 to conduct the military utility assessment of the Space Environment Network Display (SEND) initiative. Sensors were placed at Ascension Island from 1 April through 17 April 1999 in support of this assessment. Based upon the performance demonstrated during the Limited Military Utility Assessment, Detachment 1 concludes that the SEND system and concept both have military utility.					
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15. SUBJECT TERMS Scintillation, Space Weather, HF Ground Illumination Maps, UHF SATCOM Outage Maps, Ionospheric Disturbances, Total Electron content, IMS, DISS, SCINDA, SEND, PRISM					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT UNCLASSIFIED	b. ABSTRACT UNCLASSIFIED	c. THIS PAGE UNCLASSIFIED			MSgt Joel Stolzmann
			Same As Report	52	19b. TELEPHONE NUMBER (include area code) 719-567-9992

# SPACE ENVIRONMENT NETWORK DISPLAY

## LIMITED MILITARY UTILITY ASSESSEMENT



FINAL REPORT  
JUNE 1999





# **Space Environment Network Display**

## **U.S. Air Force Space Battlelab Kenney Battlelab Initiative**

### **Limited Military Utility Assessment Final Report**

**June 1999**

*Produced by:*

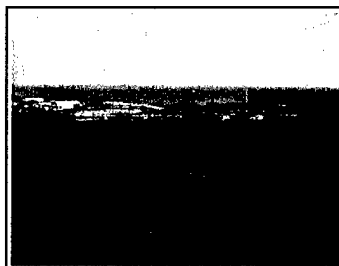
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## Executive Summary

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The US Air Force Space Battlelab designated the Detachment 1 to conduct the military utility assessment of the Space Environment Network Display (SEND) initiative. Sensors were placed at Ascension Island from 1 April through 17 April 1999 in support of this assessment.

## Conclusions and Recommendations

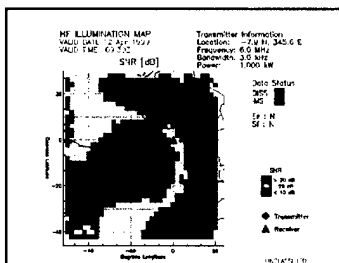
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Based upon the performance demonstrated during the Limited Military Utility Assessment, Detachment 1 concludes that the SEND system and concept both have military utility.

## Background

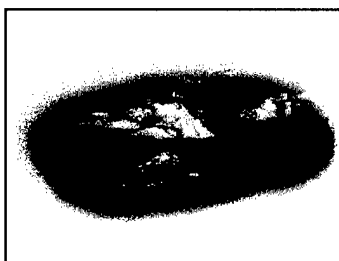
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SEND integrates new and existing space environment sensor data with models to provide graphical, web-page space environment displays to the warfighter. SEND creates products which describe Ultra-High Frequency Satellite Communication outages and High Frequency communication degradation.

## Evaluation Methodology

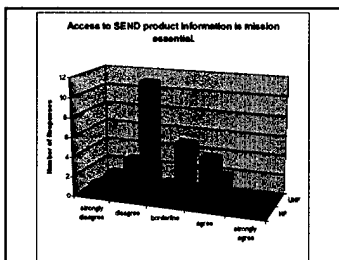
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The purpose of the SEND demonstration was to integrate sensor systems at Ascension Island, integrate the information and data network required to transfer data from the field site, and assess the limited military utility of the SEND system in accordance with the execution plan.

## Significant Results

29



Potential user impressions of SEND product utility and ease of use were compiled. The percentage of time that product information was globally disseminated was measured. The timeliness of SEND products was also determined.

## Appendices

### A: Test Event Chronology

### B: List of Acronyms

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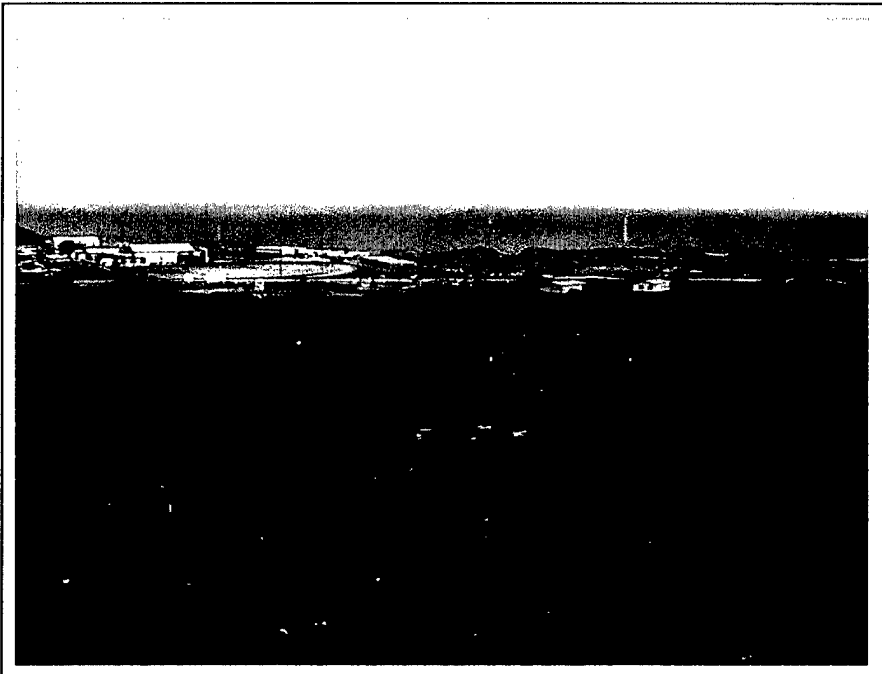
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## EXECUTIVE SUMMARY

The US Air Force Space Battlelab (AFSB) sponsored a campaign concept to direct the assessment of the Space Environment Network Display (SEND) concept. The overall objective of the campaign concept was to integrate new and existing space environment sensor data with models to provide graphical, web-page space environment displays to the warfighter via the Secret Internet Protocol Router Network (SIPRNET). This would enable operators to see if there are scintillation effects over their region of interest and to adjust their communications accordingly.

SEND is an integrated system, designed to incorporate information from three separate sensor systems and to create products which describe two space environment problems: Ultra-High Frequency Satellite Communication (UHF SATCOM) outages and High-Frequency (HF) communication degradation.

The AFSB designated Detachment 1 (Det 1) to conduct the military utility assessment. The SEND system sensors were placed at Ascension Island from 1 April through 17 April 1999 in support of this assessment.



*The SEND system uses ground-based antennae to collect ionospheric data and to predict scintillation effects on communication links.*

Set up and integration of the SEND sensor systems was completed by 29 March 1999. Data collected by the sensors was sent to the Defense Meteorological Satellite and Space Environment Support Program Office (DMSASESPO) at Schriever AFB, CO on 30 March 1999; space environment products were generated at the DMSASESPO and made available on the SIPRNET to the warfighter/user the same day. The SEND system was declared

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ready-for-assessment on 31 March 1999; the SEND demonstration began 1 April 1999.

Conclusions reached as a result of this LMUA include:

- According to the potential users polled during this LMUA, the SEND space environment product presentations have military utility in mission execution. Users agreed that it was easy to understand the SEND displays.
- HF Illumination maps were placed onto the Internet 99% of the time; UHF SATCOM Outage maps were placed onto the Internet 94% of the time. It took an average of 16.5 minutes to transfer UHF SATCOM scintillation information from the sensor field site to the SEND product display on the Internet. It took no more than one hour to transfer HF Illumination propagation information.

**Based upon the performance demonstrated during the LMUA and upon the requests for space environment information which surfaced after the LMUA, Det 1 concludes that the SEND system and concept both have military utility.**

Six recommendations were forwarded to the AFSB:

1. The accuracy of the data presented on the SEND space environment products should be rigorously determined.
2. A focused effort to improve scintillation model fidelity using measured data should be undertaken.
3. Efforts to make the data transmission path more robust and the product displays more accessible should be undertaken.
4. Though intentionally not included as part of the LMUA, potential users expressed great interest in also obtaining scintillation-based single channel Global Positioning Satellite (GPS) navigation error information. Detailed user requirements must still be obtained, but the interest in this type of product warrants further examination.
5. Space environment information will be much more valuable to warfighters when it can be provided in advance of missions; this forecasting capability should be paramount in any follow-on development activities.
6. Poll potential users (and develop a consensus among them) to finally develop a formal set of space environment product information requirements.



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# CONCLUSIONS AND RECOMMENDATIONS

## Conclusions

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- According to the *potential users* polled during this LMUA, the SEND space environment product presentations **have military utility** in mission execution.

The principal purpose of the SEND LMUA was to ascertain whether the SEND system and concept had military utility. The strong performance demonstrated with respect to all the LMUA objectives is a good signal of military utility. Incontrovertible additional evidence of the SEND system and concept military utility was, however, presented in the form of the two memoranda reprinted below.

The first memorandum is from the Air Force Space Command Weather and Space Environment Operations Branch Directorate of Operations, stating that ***future gathering of ionospheric information in the equatorial region is critical***; they request that SEND system components be left behind at Ascension Island. The second memorandum is from the Joint Task Force – Southwest Asia Director for C4 Systems, stating that ***scintillation and propagation forecasts are critical data sets***, and requesting 55<sup>th</sup> Space Weather Squadron (SWXS) support in the development of those forecasts.

DEPARTMENT OF THE AIR FORCE  
HEADQUARTERS AIR FORCE SPACE COMMAND

14 Apr 99

MEMORANDUM FOR AFRL/VSBP  
ATTN: DR TERRY BULLETT

FROM: HQ AFSPC/DORW  
150 Vandenberg Street, Suite 1105  
Peterson AFB CO 80914-4250

SUBJECT: Ascension Island Digital Ionospheric Sounding  
System (DISS) and Ionospheric Measuring System (IMS)

1. Ascension Island affords us an ideal location for gathering ionospheric data in the equatorial region. The concerns we had about leaving the DISS and IMS at Ascension Island after the Space Environment Network Display (SEND) demonstration have been addressed and we feel we can deal with any issues that pop up. You may proceed with any modifications to existing Memorandums of Agreement (MOA) or create new MOAs, if necessary, to ensure the DISS and IMS remain at Ascension Island after the SEND demonstration ends.

2. We understand the importance of this effort and my point of contact, Maj Randy Thomas, stands ready to provide assistance to make this happen. He can be reached at DSN 692-3242.

//Signed//  
STEPHEN S. CARR, Lt Col, USAF  
Chief, Weather and Space Environment  
Operations Branch  
Directorate of Operations

cc:  
SMC/CIDM (Mr. Ray Lopez)

UNITED STATES CENTRAL COMMAND  
JOINT TASK FORCE – SOUTHWEST ASIA  
APO AE 09871

14 May 99

MEMORANDUM FOR 14AF/DOOW

FROM: JTF-SWA/J6

SUBJECT: Request for Space Environment Support

1. JTS-SWA requires UHF SATCOM scintillation forecasts and HF radio propagation forecasts (see paragraph 2), the Space Environment slide currently provided to the Pentagon and the Space Environment Summary and Outlook product. These products need to be provided via SIPRNET and updated daily. Request this support begin NLT 19 May 99.
2. Request UHF SATCOM scintillation forecasts for six ground stations, each communicating with six different satellites. The total number of UHF SATCOM scintillation forecasts needed is 108. Also request HF radio propagation forecasts for ten HF circuits. The total number of HF radio propagation forecasts needed is 30. The periods for these forecasts should be 24, 48, and 72 hrs. Specific information concerning both the UHF SATCOM and HF radio circuits is classified and has already been provided to the 55<sup>th</sup> Space Weather Squadron.
3. My POC for this request is SSgt Gould (DSN 318-435-8782).

//Signed//  
RONNIE D. HAWKINS, JR, Col, USAF  
Director, C4 Systems

cc:  
HQ AFSPC/DRFF  
HQ AFSPC/DORW  
55 SWXS/CC

- Users agreed that it was easy to understand the SEND displays.
- *HF Illumination* maps were placed onto the SIPRNET web page for global dissemination **48%** of the LMUA demonstration period. *UHF SATCOM Outage* maps were placed onto the SIPRNET **28%** of the LMUA demonstration period. Unanticipated connectivity problems forced placement of sanitized SEND product information on an Internet web page to effect the LMUA. *HF Illumination* maps were placed onto the Internet **99%** of the time; *UHF SATCOM Outage* maps were placed onto the Internet **94%** of the time.
- It took an average of 16.5 minutes to transfer UHF SATCOM scintillation information from the sensor field site to the SEND product display on the Internet; it took 21.3 minutes to transfer the same data onto the SIPRNET. It took no more than approximately one hour to transfer HF Illumination propagation information.
- The 99% and 94% availability of space environment products reflect favorably upon SEND system component reliability.

**Based upon the performance demonstrated during the LMUA and upon the requests for space environment information which surfaced after the LMUA, Det 1 concludes that the SEND system and concept both have military utility.**

## Recommendations

7. *The accuracy of the data presented on the SEND space environment products has never been rigorously determined. During any follow-on development activity, a concentrated effort should be made to verify that the signal-to-noise ratio (SNR) presented on the HF Illumination maps match the SNR degradation in the real world, and that the scintillation watch/warning areas presented on the UHF SATCOM Outage maps match the scintillation storms in the real world. Furthermore, a concentrated effort to validate that the color coding on both the HF Illumination and the UHF SATCOM Outage maps properly reflect the effects on warfighter communications equipment should also be accomplished.*
8. *There are large discrepancies between the current scintillation and propagation predictions and the scintillation and propagation levels measured by the SEND system. Det 1 recommends undertaking a focused effort to improve model fidelity using measured data.*

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9. The quality of space environment data is intimately tied to the speed of data transfer. *The SIPRNET/Meteorological Dissemination System (MDS) network employed during the SEND LMUA was a critical node which consistently failed during the demonstration.* Efforts to **make the data transmission path more robust and the product displays more accessible** should be undertaken. Efforts to **increase processor speed to accommodate map generation every fifteen minutes** (vice the thirty-minute interval demonstrated during the LMUA) should also be undertaken.
  10. Though intentionally not included as part of the LMUA, potential users expressed great interest in also obtaining scintillation-based single channel GPS navigation error information. Detailed user requirements must still be obtained, but the interest in this type of product warrants further examination.
  11. Space environment information will be much more valuable to warfighters when it can be provided in advance of missions. As currently configured, however, *the SEND system is incapable of accurately forecasting space environment conditions.* Though much work – development of a more rapid and robust data transfer method, and improvement of existing models through comparison to measured data – must still be accomplished before build-up of a reliable forecasting method can be started. This **forecasting capability should be paramount in any follow-on development activities.**
  12. Finally, one of the most difficult aspects of the LMUA was that *there was no pre-defined user population* (and hence, no pre-defined user requirements to test to). Now that the LMUA has helped locate a set of potential users, it should be possible, by polling those users and developing a consensus among them, to finally **develop a formal set of space environment product information requirements.** This should be done prior to the start of any follow-on development activities.

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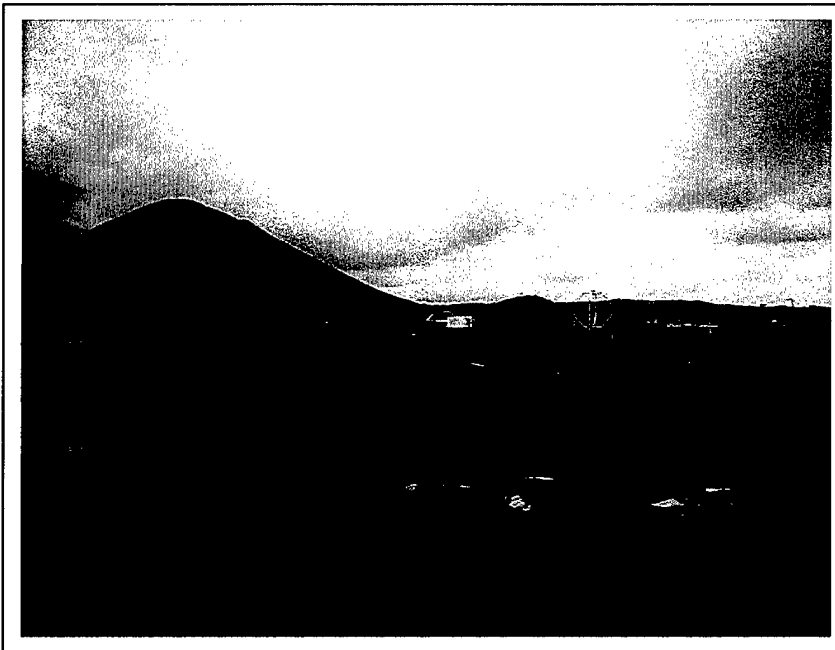
# BACKGROUND

## Tasking

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On 14 May 1998, the AFSB sponsored a campaign concept to direct the assessment of the SEND concept. The overall objective of the campaign concept was to integrate new and existing space environment sensor data with models to provide graphical, web-page space environment displays to the warfighter via the SIPRNET. This would enable operators to see if there are scintillation effects over their region of interest and to adjust their communications accordingly.

The AFSB is a component of the Space Warfare Center. The AFSB mission is to identify space operations and logistics concepts and rapidly measure their potential for advancing the Air Force core competencies – Air and Space Superiority, Global Attack, Rapid Global Mobility, Precision Engagement, Information Superiority, and Agile Combat Support – and joint warfighting using field ingenuity modeling and simulation, and actual employment of exploratory capabilities in operational environments. The AFSB focus is to explore concepts which advance those Air Force core competencies. To select concepts of potential value, the AFSB actively solicits initiative ideas, and funds selected initiatives for assessment.



*SEND system components were placed at Ascension Island in support of the LMUA.*

The SEND initiative to assess the military utility of globally-distributed space environment products was categorized as a Kenney Battlelab Initiative (KBI). KBIs are innovations led by the Battlelab Director, coordinated, where possible, with other Battlelabs, and funded by a major command.

The AFSB designated Det 1 to conduct the KBI military utility assessment. The purpose of a Military Utility Assessment (MUA) is to prove if an idea, concept,

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system, method, or process can improve the ability of the warfighter to complete his or her mission. For reasons described in the Limitations and Constraints section of this document, the SEND initiative assessment was a Limited Military Utility Assessment (LMUA). The SEND system sensors were placed at Ascension Island from 1 April through 17 April 1999 in support of this LMUA.

## **System Description**

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SEND is an integrated system, designed to incorporate information from three separate sensor systems and to create products which describe two space environment problems: UHF SATCOM outages and HF communication degradation.

The outages and degradation are the result of ionospheric disturbances. Ionospheric disturbances are storm-like phenomena that arise and dissipate according to solar activity. These storms move through the ionosphere in an easterly direction with the Earth's wind pattern similar to a meteorological storm.

Ionospheric disturbances can cause rapid phase and amplitude fluctuations of satellite signals observed at or near the earth's surface; these fluctuations are known as *scintillation*. The most intense natural scintillation events occur during nighttime hours within 20° of the earth's magnetic equator, a region encompassing more than 1/3 of the globe's surface. (Scintillation activity is also observed in high latitudes but the SEND scintillation model is not applicable for that region.) Scintillation affects radio signals up to a few gigahertz (GHz) frequency and seriously degrades and disrupts satellite-based navigation and communication systems.

The ionospheric disturbances are induced by solar activity. Usually, communications can bounce off the ionosphere, as if it were a mirror; solar activity causes the ionosphere to act like a corrugated surface, disturbing signal transmission paths. The ionosphere can also become opaque to certain frequencies, making communication difficult or impossible.

Solar activity peaks on an eleven-year cycle, called the Solar Maximum; as an example, the changes in solar activity during the 1979 cycle are shown in Figure 1. Any increase in activity may greatly affect communication performance. The next Solar Maximum will occur in 2000. Conducting the SEND demonstration in April 1999 afforded the opportunity to assess scintillation at levels lower than peak activity.



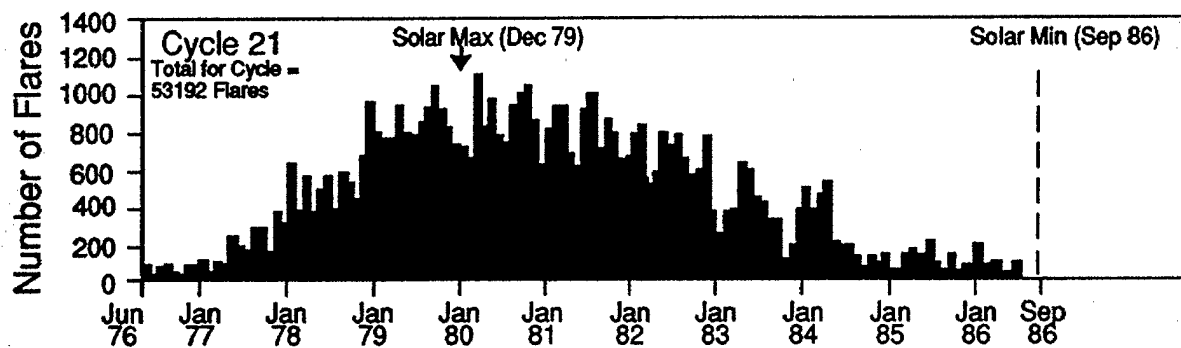


Figure 1. Solar Activity Increases during the Eleven-Year Solar Cycle.

## UHF SATCOM

Scintillation produces significant UHF SATCOM signal distortions and drop-outs. Those distortions, in turn, produce significant impacts on communication transmission and reception, namely:

- Degrade Navigation Accuracy
- Degrade Surveillance Radar Target Detection and Track
- Impair Visibility for Space Surveillance Radars

Scintillation activity is most pronounced within 20 degrees of the earth's equator. Scintillation-induced regional outages may last for extended periods (hours). Scintillation effects on UHF SATCOM are significant only during the night (from one hour before dusk until one hour after dawn).

The effects on UHF SATCOM transmission are a function of scintillation level. Low scintillation may delay message transmission. High scintillation levels may completely hinder transmission, as shown in Figure 2.

The UHF SATCOM system is currently 250% over-subscribed. Conservative estimates assume the need in 2010 will be thirteen times current capacity. The mission impacts due to UHF SATCOM outages cannot be overstated:

*"The requirements for UHF SATCOM are stronger today than anytime in the history of satellite communications."*

CDR Austin Boyd, 1997

## SATCOM MESSAGE ERRORS DUE TO SCINTILLATION

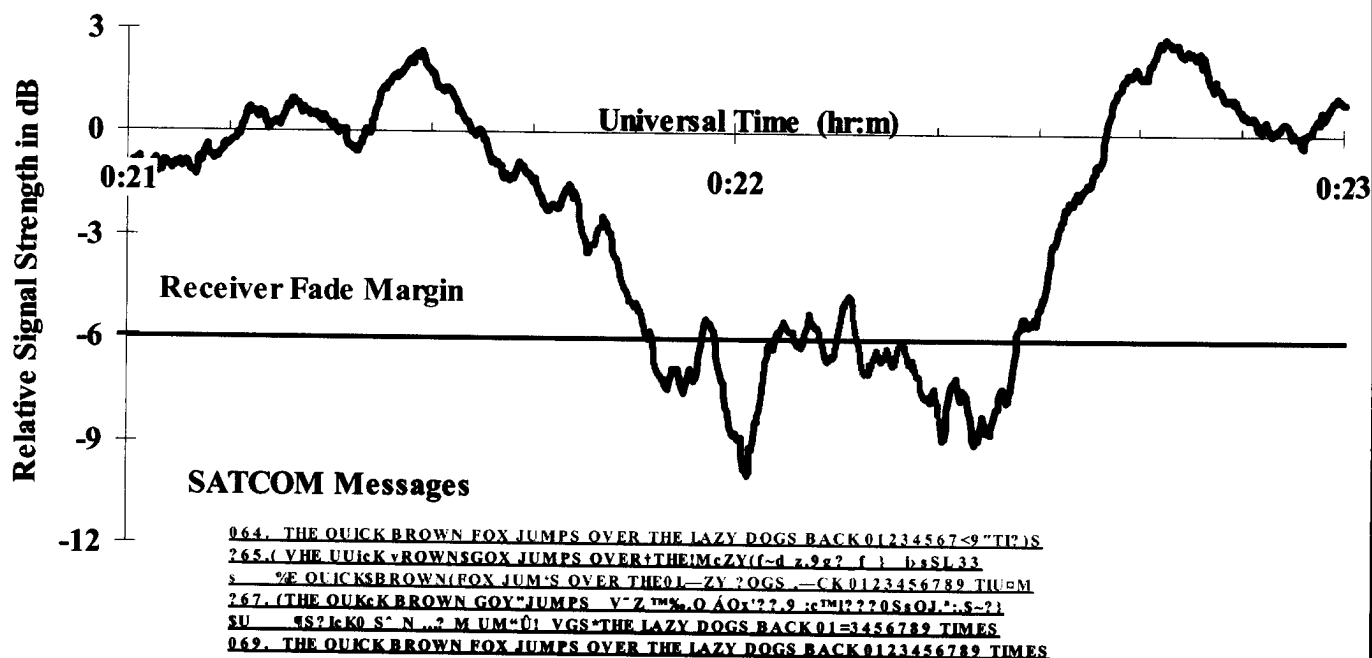


Figure 2. Scintillation Effects Can Completely Deny Communications.

*"The digitized battlefield of 2010 will largely ride UHF SATCOM and other narrowband systems for marine and ground mobile forces that cannot carry the parabolic dish antennas or phased arrays needed for all other SATCOM systems."*

CDR Austin Boyd, 1997

From a UHF SATCOM operator perspective, the presence of scintillation is currently not verifiable. Most communication problems are, therefore, attributed to either operator error or equipment malfunctions. There has simply been no way for mission planners or operators to verify the presence of scintillation-based disturbances.

The purpose of the Scintillation Network Decision Aid (SCINDA) sensor system is to display scintillation-induced communication effects on color-coded maps. SCINDA develops an ionospheric model of the space environment by measuring the total electron content from the SCINDA sensor system to a specific UHF SATCOM satellite.

SCINDA provides a graphical interface allowing the operator to define a desired communication link, which includes ground-station coordinates, radio frequency and a comprehensive satellite database, complete with daily ephemeris updates. The model then displays the communication links between the ground stations and satellites, color-coded yellow if the link passes through a moderate scintillation structure, and red if the link passes through a significant scintillation structure. For the SEND demonstration, SCINDA displayed UHF SATCOM link information on 2-D maps (similar to the one shown in Figure 3).

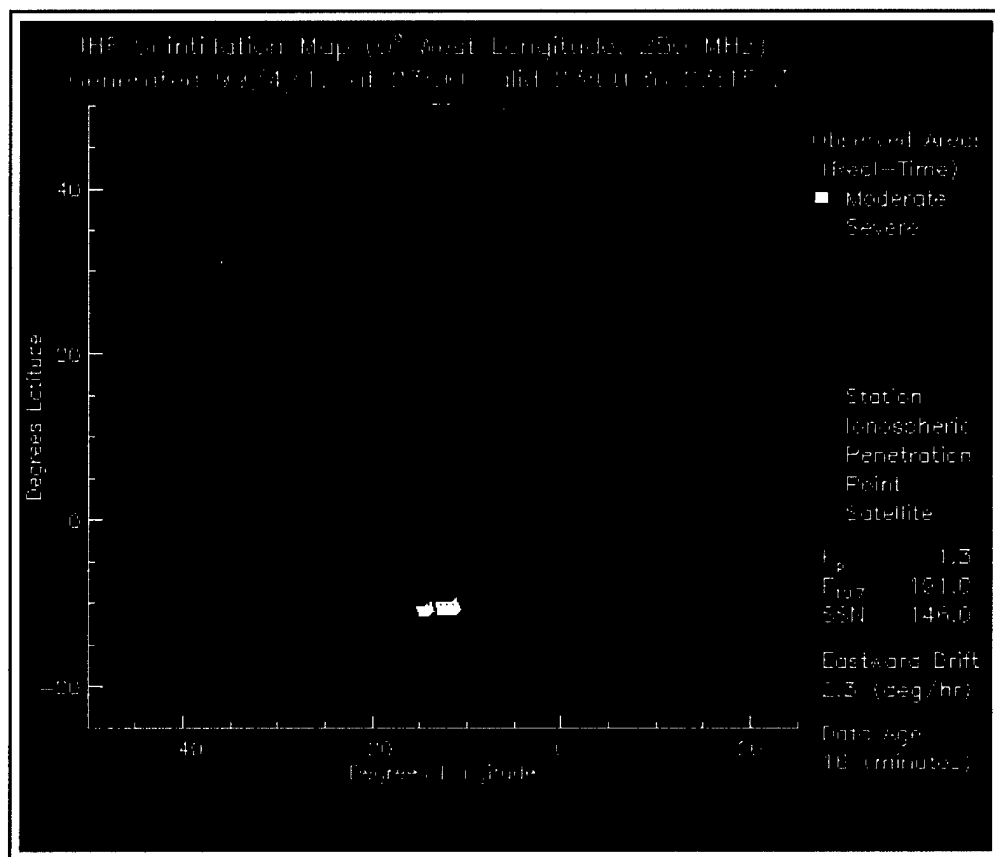


Figure 3. SCINDA Produced 2-D UHF SATCOM Outage Maps for the SEND Demonstration.

Outage maps are generated for operational purposes. The outage regions are frequency-corrected geometric projections from a selected satellite to the ground. If the operator sets the color map thresholds properly for a given user, the red-yellow-clear areas can be immediately interpreted as regions of severe, moderate and little effect on the operator's system.

## HF Communication

The ionospheric disturbances discussed in the previous section will also adversely affect HF communication. Since the ionosphere is an essential component of every HF link, ionospheric knowledge is the limiting factor for HF.

Currently, HF communications links are inexpensive, are difficult to deny, require low bandwidth, and are nearly omnipresent. In the future, conservative predictions all point toward continued US and foreign reliance on HF communication.

The effects due to ionospheric conditions on specific HF frequencies are both very complex and frequency dependent. The SNR for different frequency signals from the same transmitter may vary greatly, as shown in Figure 4.

The Digital Ionospheric Sounding System (DISS) and Ionospheric Measuring System (IMS) work in concert to generate the HF Illumination maps shown in Figure 4. The DISS measures the ionospheric electron content directly above the sensor site as a function of altitude – but only up to the maximum “electron content” altitude. The IMS measures total ionospheric electron content from the sensor to various GPS communication satellites. The Parameterized Real-time Ionospheric Specification Model (PRISM) algorithms employ the IMS detailed-single-axis information and the DISS coarse-multiple axis information to generate an accurate model of the ionosphere. The HF Raytrace algorithms use the PRISM model to generate the HF illumination maps.

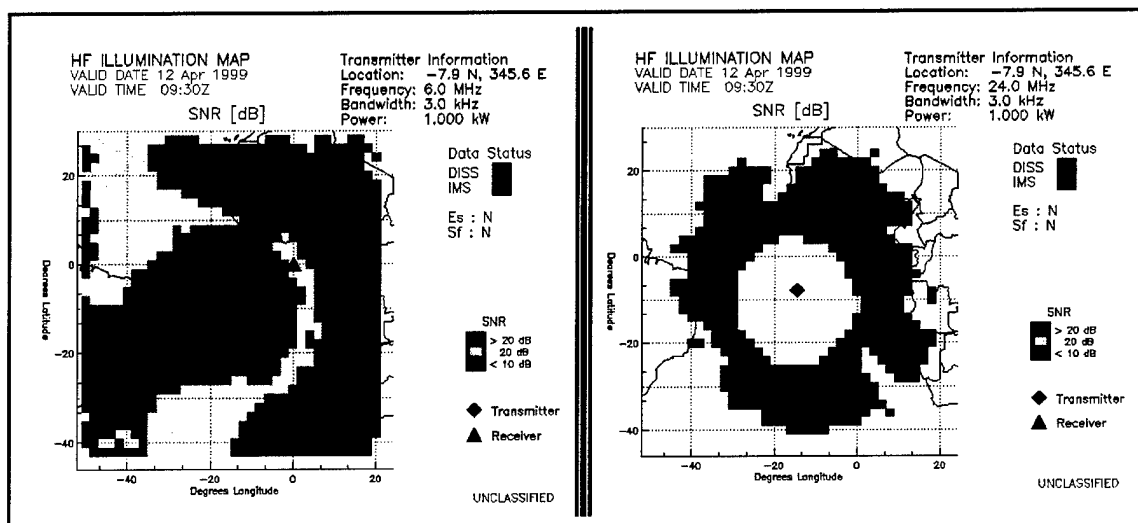


Figure 4. HF Performance Is Frequency Dependent.

## Integrated SEND System

The SEND system integrates the three sensor systems (DISS, IMS, and SCINDA) and the algorithms resident on the PRISM create and disseminate space environment descriptions of ionospheric disturbance effects on UHF SATCOM and HF communications. The DISS, IMS, and SCINDA sensor systems were placed in the field; the configuration of the field site and data linkage is shown in Figure 5.

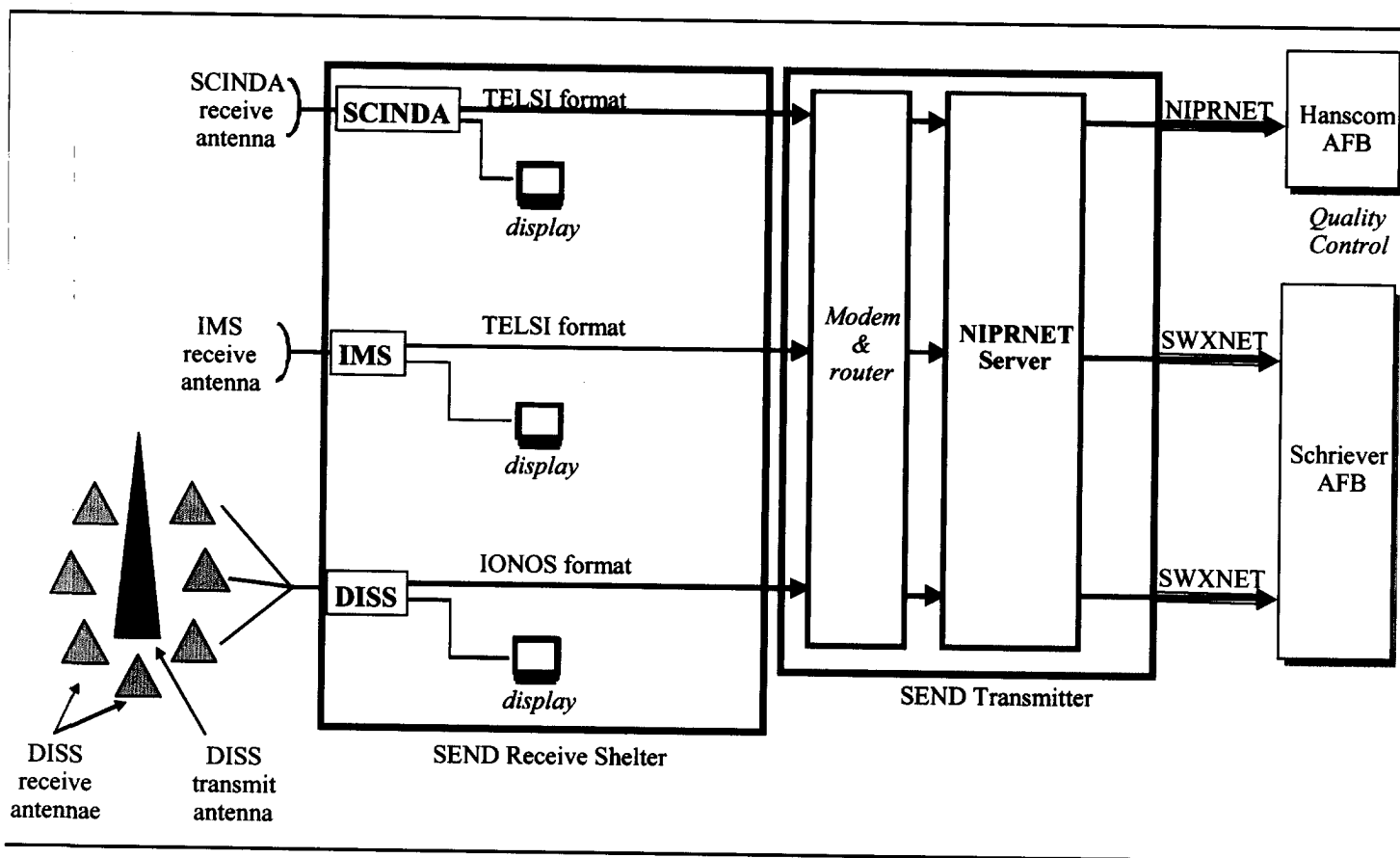


Figure 5. Sensor Data Will Flow from the Antennae onto the Space Weather Net.

A Silicon Graphics Octane processor, which hosts the PRISM, SCINDA, and HF Raytrace applications, was located at Schriever AFB, Colorado. The configuration of the data paths from the field site through Hanscom AFB to Schriever AFB is shown in Figure 6.

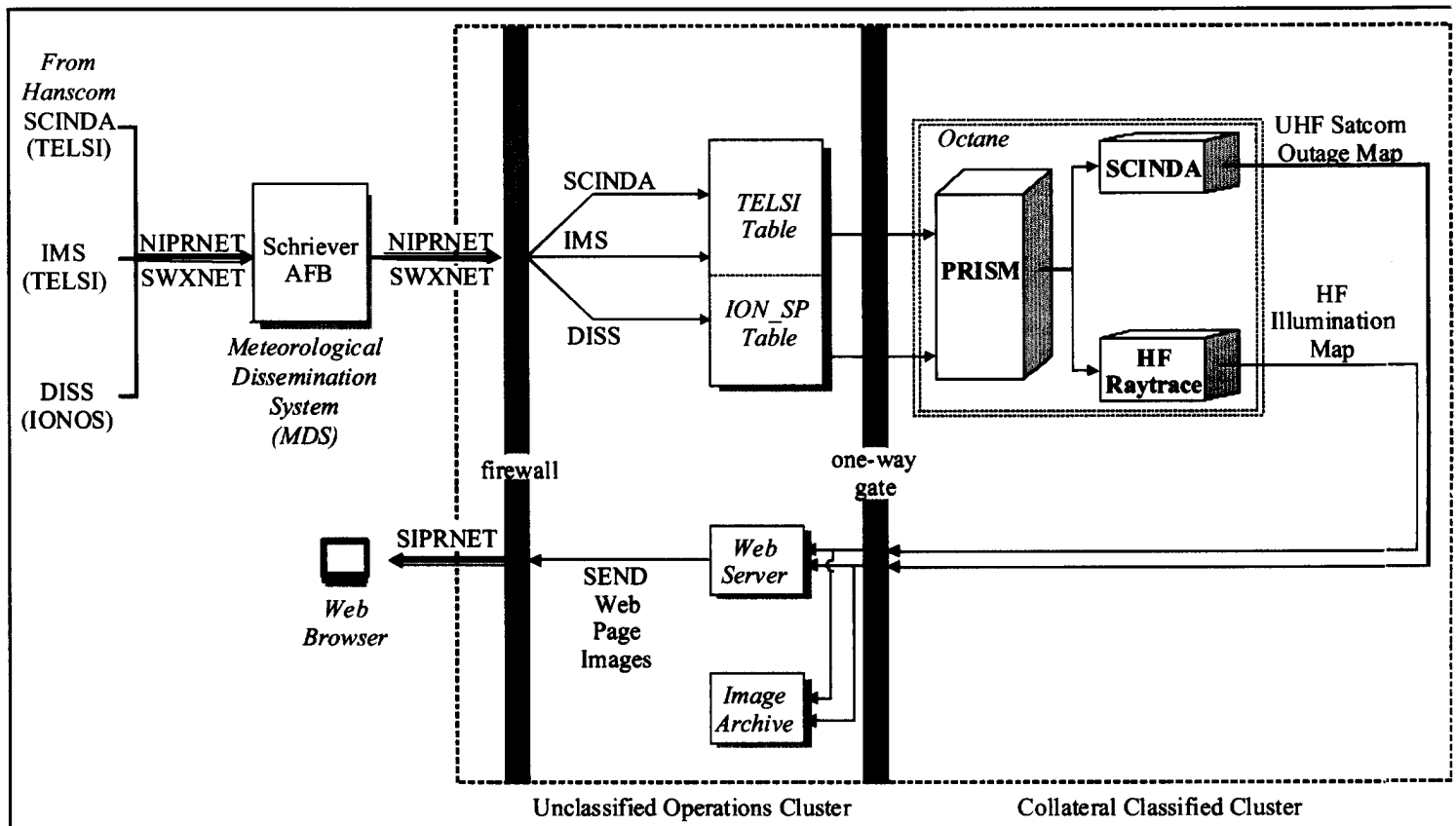


Figure 6. Sensor Data Will Flow through Two Clusters at Schriever AFB.

Once the sensor data software file is placed onto a Nonclassified Internet Protocol Router Network (NIPRNET)-accessible processor, the file is pulled into processors at Hanscom AFB for data quality control. (This is for SCINDA sensor data only. The purpose is to both conduct data quality control and add global parameters, such as the magnetic activity level and satellite orbital elements.) Once the data has completed that pre-processing, the files are once again made NIPRNET-accessible. The processed files are then pulled through the Schriever AFB firewall into the Unclassified Operations Cluster. Once placed onto the database, the data is pulled through a one-way gate onto the Octane computer. ("One way" implies that unclassified data can be pulled through to a classified system, but cannot be released the other way back onto an unclassified system.) Upon completion of model and product generation, the most recent products are placed onto a

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classified web server, making them available worldwide via the SIPRNET. All products are also placed onto a classified image archive processor, to be accessed as required for assessment data analysis.

The SEND system processors generate their ionospheric models and the maps derived from those models at set intervals (an asynchronous system). The maps will be generated regardless of the availability of new sensor data. Given the asynchronous nature of the SEND system, it could therefore take anywhere from 30 to 56 minutes for a given environmental data event to be presented on the SEND SIPRNET web page.

The PRISM and SCINDA processors use historical data to create an ionospheric model. Each processor uses eight past sets of data to populate its algorithms. The loss of a single data set to either processor is not significant; multiple data set loss will, however, seriously degrade the fidelity of the derived products.

## Participants

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### Space Battlelab, Schriever AFB, CO

- Overall initiative oversight and management
- Security oversight
- Provision of funds and cost management
- Final decision authority on all initiative matters



### Air Force Research Lab, Hanscom AFB, MA

- Operations and maintenance of all SEND components
- Integration of sensors, processors, and related software
- Subject matter experts and system trainers



### Detachment 1, Kirtland AFB, NM

- LMUA development management and execution
- Logistics and operations planning and management
- Data management, analysis, and report production

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**SSSG Det 11, Peterson AFB, CO**

- Coordinate and provide all communications connectivity
- Ensure accreditation of all SEND processors for SIPRNET connectivity
- Design SEND product web page
- Subject matter experts

**Defense Meteorological Satellite and Space Environment  
Support Program Office, Schriever AFB, CO**

- Distribution of SEND products

**General User Population**

- Weather Forecasters
- Communications Operators
  - HF
  - UHF SATCOM
- Planning Cell Personnel
  - Task Order Developers
  - Air Operations Center Planning Cell Communication Operators
- Operations Cell Personnel
  - Tanker-Airlift Control Center (TACC) Personnel
  - Forward Operations Center Personnel
  - Rear Operations Center Personnel
  - Frequency Managers
- Decision Makers
  - Commanders in Chief (CINCs)
  - Services



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# EVALUATION METHODOLOGY

## Introduction

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This section describes the LMUA accomplished using data from the SEND system demonstration; it includes a top-level discussion of the assessment methodology and limitations, a summary of the assessment objectives, and a detailed description of the data products, data collection methods, and assessment activities required to support each objective.



*SEND system components were housed in a dedicated shelter on Ascension Island.*

### **Mission Statement**

**Det 1 assessed the military utility of the SEND system during an overseas demonstration from 1 April through 17 April 1999 on Ascension Island.**

### **Military Utility**

For purposes of the SEND assessment, "military utility" was defined as follows:

- The decision maker, user, operator must have believed that the information provided improved their ability to accomplish their mission.
- The interface for presenting information must have been reasonably simple to use.
- The information must have been made available soon enough to be included in mission processes.
- The system providing the information must have been dependable.
- The information presented must have been accurate.

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## Operators, Users, and Decision Makers

To successfully evaluate military utility, specifying an appropriate target population was critical. In its final configuration, the SEND system products would probably not be viewed by actual UHF SATCOM or HF radio *operators*, but would instead be viewed by *users* inside mission planning/operations cells. Those users and the *decision makers* above them in the military hierarchy would access the SEND products and pass on, as necessary, the derived space-environment information to the radio operators under their command.

The users and decision makers viewing SEND products on the SIPRNET were the only participants who had access to the assessment on-line questionnaire. Those users and decision makers, therefore, played a critical active role in the successful completion of the LMUA. Where possible, the assessment team also pursued operator opinions through follow-on interviews. Other users and decision makers without access to the SIPRNET were provided archived space environment products and a space environment introduction "roadshow" briefing and asked to respond to questionnaires based upon that information.

It should be noted again that the sensors were placed on Ascension Island during the overseas demonstration. SEND products, when generated, were therefore focused on Ascension Island. The small fraction of users and decision makers concerned with that theater's environmental effects were able to assess the utility of the SEND information with respect to actual missions. All other users and decision makers around the globe were forced to assess the utility of the SEND information with respect to hypothetical missions sets.

The population requested to voluntarily support the assessment is summarized below:

- CINC's Decision Makers
  - J2 – Intelligence
  - J3 – Operations
  - J5 – Planning
  - J6 – Command, Control, and Communications
- Frequency Managers
  - Naval Computer and Telecommunications Area Master Station
  - Joint Frequency Management Organization
- Mission Planning
  - Air Operations Center Personnel

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- Joint Operations Center Personnel
  - Joint Intelligence Command – Pacific
  - UHF SATCOM & HF Communications Operators
    - Pacific Fleet
    - Special Ops Command – Pacific
    - Pacific Air Forces
    - Southwest Asia – Area of Responsibility
    - US Armed Forces – Europe
    - Alaska Command
    - Marine Forces – Pacific

## **Objectives and Methodology**

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The primary goals of the SEND demonstration assessment were to:

- Assess utility of the SEND concept.
- Assess the system's ease of use.
- Assess the time UHF SATCOM Outage map and HF Illumination map products were available worldwide on the SEND SIPRNET web page.
- Assess the timeliness of information provided.
- Assess the dependability of the SEND system.
- Collect ancillary information on system setup, logistics, transportability, and integration.

The primary goals of the assessment were formally refined into five objectives, shown in the box below.

### **SEND LMUA OBJECTIVES**

- 1.) Determine the **utility** of the SEND space environment product presentations in *mission planning and conduct*.
- 2.) Determine the **ease** with which new users can *effectively operate* the SEND system.
- 3.) Determine the **percentage of time** SEND product information is placed onto the SIPRNET web page for global dissemination.
- 4.) Determine the **time required to transfer** space environment information from the sensor *field site* to the *SEND* product display on the *SIPRNET*.
- 5.) Determine the **percentage of potential operational time** during which the SEND system is **operational**.

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## Event Constraints and Limitations

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The SEND initiative assessment was a Limited MUA. The “limited” label was attached to the title for two primary reasons:

- 1) The user population required to assess the utility of the SEND system concept was not defined before preparing the assessment, but was only finalized during assessment execution. This resulted in assessment by a less-than-optimal population.
- 2) The system under test was not capable of providing individually-tailored products in response to user requests, which could be partially responsible for perceived decrease in SEND *concept* military utility (when, in reality, the decrease should have been attributed to immaturity of the SEND *system* being employed for assessment).

In addition, there were a number of limitations to and constraints in assessing the SEND system.

- The optimal sensor location for the demonstration was the Southwest Asia Area of Responsibility (SWA-AOR), placing the sensors in close proximity to a large swath of potential users. Because of real-world constraints, however, sensors were not given host nation approval to be located into the SWA-AOR, and instead had to be placed on Ascension Island. Therefore, the system was not assessed by users who could use the information in their current operations. This limited assessment instead was forced to depend upon creative thinking of users in other parts of the world.
- Data collection was dependent upon users and operators to assess military utility. User participation was not guaranteed, was strictly on a voluntary basis, and, because of real-world contingencies, was very difficult to solicit.
- There were no backup systems available to replace sensor hardware, system processors, or communication links when they failed during the demonstration.
- The information to be transferred from the field site to the DMSASESPO was affected by the same scintillation displayed on SEND product maps. (In that case, sensor data never made it to Schriever AFB, and product maps were never generated.)
- The *accuracy* of the SEND limited communication and complete outage areas presented on the space environment products was not evaluated.

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- The communications path from the SEND sensors through Schriever AFB to the SIPRNET was not a dedicated path. The inability to utilize those links (due to real-world constraints) was not a SEND system issue, but was nonetheless allowed to affect the SEND concept assessment.
  - Data collection was dependent upon the storms that cause scintillation. The more storms that occurred, the more opportunity there would be to assess military utility. Since the space environment was calm for a portion of the demonstration period, the opportunity to assess military utility at those times was diminished.
  - User experience and knowledge base had an affect on the results of the assessment. It was desirable to enlist users who had an understanding of the problem and could work with the operators to adjust their communication link to avoid the scintillation effects. The assessment team worked to educate the potential user population by ensuring that, at a minimum, each user was provided the SEND introduction briefing (which included sample archived maps). Still, most users had less than an operational understanding of the scintillation problem or the SEND solution.

## **Field Operations**

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The purpose of the April SEND demonstration was to:

- 1) Integrate the DISS, IMS, and SCINDA sensor systems at Ascension Island.
- 2) Integrate the information and data network required to transfer data from the field site through DMSASESPO to the SIPRNET.
- 3) Assess the limited military utility of the SEND system in accordance with the execution plan.

The small island of Ascension lies in the South Atlantic (7° 56'S, 14° 22'W), some 750 miles northwest of the Island of Saint Helena and covers an area of 35 square miles. Ascension is a rocky peak of purely volcanic origin with its base just west of the mid-Atlantic ridge. Much of the island is covered by basalt lava flows and cinder cones. The highest point (Green Mountain) at some 2817 ft is covered with lush vegetation which, with each rainy season, is increasingly spreading throughout the island. The climate is sub-tropical (temperatures at sea level are 68-88F). Showers occur

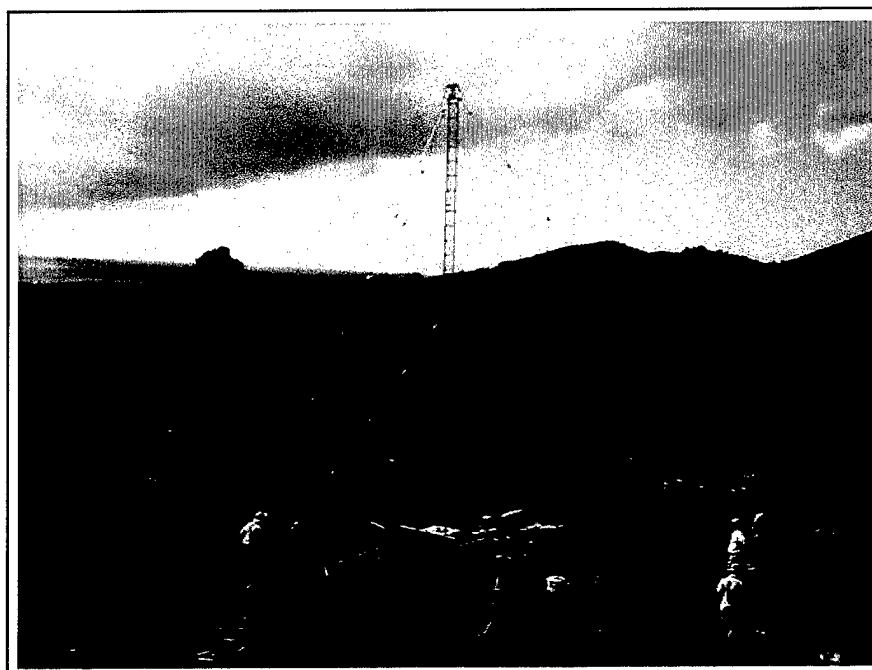
throughout the year with slightly heavier rains in the January-April period. A picture of the island is shown in Figure 7.



*Figure 7. SEND Sensors Were Placed on Ascension Island.*

The equipment sent to Ascension Island consisted of 14 pieces (8,146 lbs., 692 cubic feet). The equipment was shipped from Hanscom AFB to Patrick AFB via commercial truck for airlift by Air Material Command (AMC) to Ascension Island. The SEND demonstration sensor placement team – one AFSB, one Det 1, and four Air Force Research Laboratory (AFRL) personnel – departed for Ascension Island on 23 March 1999. Delivery, unpacking, and installation of equipment began immediately upon arrival; a shelter provided by personnel at Ascension Island was reconfigured by the SEND team to accommodate the AFRL SEND equipment suite.

Installation of transmitting antennae involved first laying out anchor and antenna points, then installing the anchors. The final hoisting of the 40-foot antenna required all AFRL and Det 1 personnel and use of both a “comalong” and a “gin pole”. Assembly and installation of the receiving antennae required three people for two days. Set up and integration of the DISS, IMS, and SCINDA



*AFRL and Det 1 personnel assisted in erecting the DISS transmit tower.*

systems was completed by 29 March 1999. Data collected by the sensors was sent to the DMSASESPO at Schriever AFB, CO on 30 March 1999; space environment products were generated at the DMSASESPO and made available on the SIPRNET to the warfighter/user the same day. The SEND system was declared ready-for-assessment on 31 March 1999; the SEND demonstration began 1 April 1999.

Fine tuning and troubleshooting of the DISS receive antennae continued through 3 April 1999. Routine maintenance of the antennae connections and anchors continued throughout the demonstration. The decision to leave the system in an operational status at the conclusion of the demonstration decreased the amount of equipment returned to 5 pieces (2,420 lbs., 263 cubic feet); the equipment arrived back at Hanscom AFB on 20 May 1999.

The IMS system was housed in the HF receiver building. The IMS antennae were co-located with the IMS. Approximately two miles away, the DISS and SCINDA systems were housed in the dedicated shelter. The SCINDA and DISS receive antennae were co-located near the shelter; the DISS transmit tower was located approximately 1000 feet from the shelter. The systems were networked in accordance with the SEND system configuration shown in the previous section.

While sensor and processor preparation was underway, Det 1 personnel began soliciting inputs from potential users. Users were introduced to the SEND concept and products, then requested to fill out the LMUA questionnaire. Det 1 personnel also tracked processor and communication link status, and SEND product availability at Schriever AFB. Finally, Det 1 personnel

disseminated e-mail and voice-mail messages soliciting military utility inputs from potential users worldwide. Figure 8 presents a schematic of the Det 1 personnel layout.

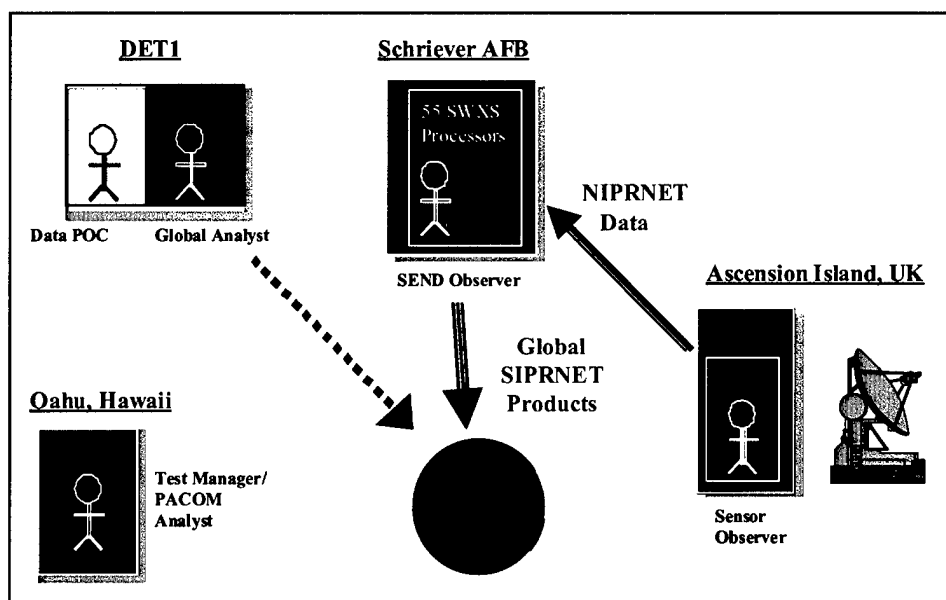


Figure 8. Det 1 Personnel Provided Worldwide SEND Assessment Support.

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## Data Management and Analysis

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To collect the data required to meet the assessment goals, the following data collection methodology were implemented:

- To measure the improvement with respect to mission performance (increase in military utility), a simple post-mission questionnaire was provided to users, operators and decision makers once they viewed the SEND products on the SIPRNET web page.
- The simple questionnaire also measured user and decision maker impressions concerning the ease of use of the SEND system.
- To document the availability of the SEND products, assessment team personnel checked whether those products were presented on the SEND SIPRNET web page during the demonstration.
- To measure the timeliness of the SEND products, assessment team personnel collected file data latency information off the SEND products to estimate the elapsed time from environmental data event until presentation on the web page.
- To qualify SEND system dependability, assessment team personnel collected component status information.

The SEND sensors were in place by 1 April 1999. The DISS and IMS began immediately creating HF Illumination maps (at thirty-minute intervals) continuously throughout the demonstration and assessment, until 17 April 1999. The SCINDA system also created UHF SATCOM Outage maps (at thirty-minute intervals) continuously throughout the demonstration and assessment.

Because of the characteristics of the model used to predict SEND scintillation, the HF Illumination maps contain SNR degradation information at all times, but UHF SATCOM Outage maps only describe scintillation from approximately three hours after sunset (2100Z at Ascension Island) until three hours before sunrise (0300Z).

Proper operation of the SEND sensors, processors, and communication links was verified by checking each day's HF Illumination and UHF SATCOM Outage maps when generated. For a variety of reasons throughout the demonstration, illumination and outage maps were not available in real or near-real time. Timelines shown in the next section both present when the individual UHF SATCOM Outage and HF Illumination maps were not available and details what specific component was responsible for the map not being available.



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Two critical elements of information were extracted from each available UHF SATCOM Outage map: the age of data printed in the map's bottom right corner, and the presence or absence of moderate and/or severe scintillation. The data age metric details the time from start of data collection through transmission to Hanscom AFB through quality control through transmission to Schriever AFB through processing on the SCINDA.

Similarly, a single HF Illumination map element of information – the system status light – is used as an equivalent measure of data age. The status lights indicate receipt of data from the DISS or IMS instruments. (Green means the incoming data is less than one hour old; yellow data is one to two hours old; and red data is older than two hours when received.) Graphs presenting information compiled from the UHF SATCOM Outage map and HF Illumination map data sets are included in the next section.

While analyzing SEND weather products, Det 1 personnel collected on-line questionnaire results from DMSASESPO, interviewed probable users from the various commands present in Hawaii, and solicited assistance from other potential users through batch e-mail messages. The operator, user, and decision maker information compiled from completed questionnaires and interviews is also presented in the next section.

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# SIGNIFICANT RESULTS

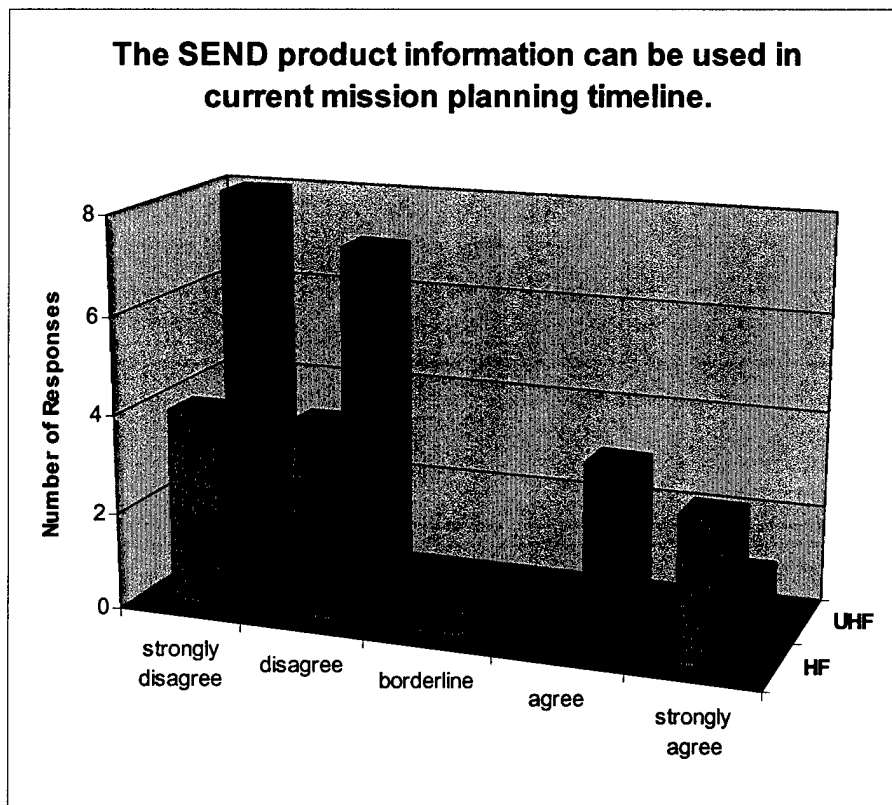
## Evaluation by Objective

### Objective 1

**Determine the utility of the SEND space environment product presentations in mission planning and conduct.**

The utility of the SEND space environment products was ascertained by examining the potential user responses to questionnaire statements. The opinions were compiled into histograms; those histograms are included in this subsection. Since the HF Illumination and UHF SATCOM Outage map questionnaires were similar in content and format, the histograms for each questionnaire statement include both HF and UHF SATCOM opinions.

The first statement on the questionnaires implied that, "The SEND product information (either HF Illumination or UHF SATCOM Outages) can be used to support the current mission planning timeline." The compiled opinions of the potential users are shown in Figure 9.



According to potential users, the SEND space environment products are not of great value in mission planning. Three separate questionnaires pinpointed why this is so: each said that mission planning (from a frequency management standpoint) was usually done 30 days in advance of mission execution. Systems like SEND, which are currently incapable of long-range forecasting, simply cannot support such planning requirements.

Figure 9. Potential user impressions of SEND value to mission planning.

The second questionnaire statement was, "The SEND product information can be used to support the current mission execution timeline." The compiled opinions of the potential users with respect to that statement are shown in Figure 10.

According to potential users, the SEND space environment products are of value in mission execution. In addition to the opinions shown in the histogram, respondents also wrote salient comments with respect to the second questionnaire statement.

- ❑ *Can be used to order timely frequency shifts.*
- ❑ *Can be used to update PACOM G6 for daily briefing with Theater CISR Command Center.*
- ❑ *Can be used for real-time frequency selection and command & control.*

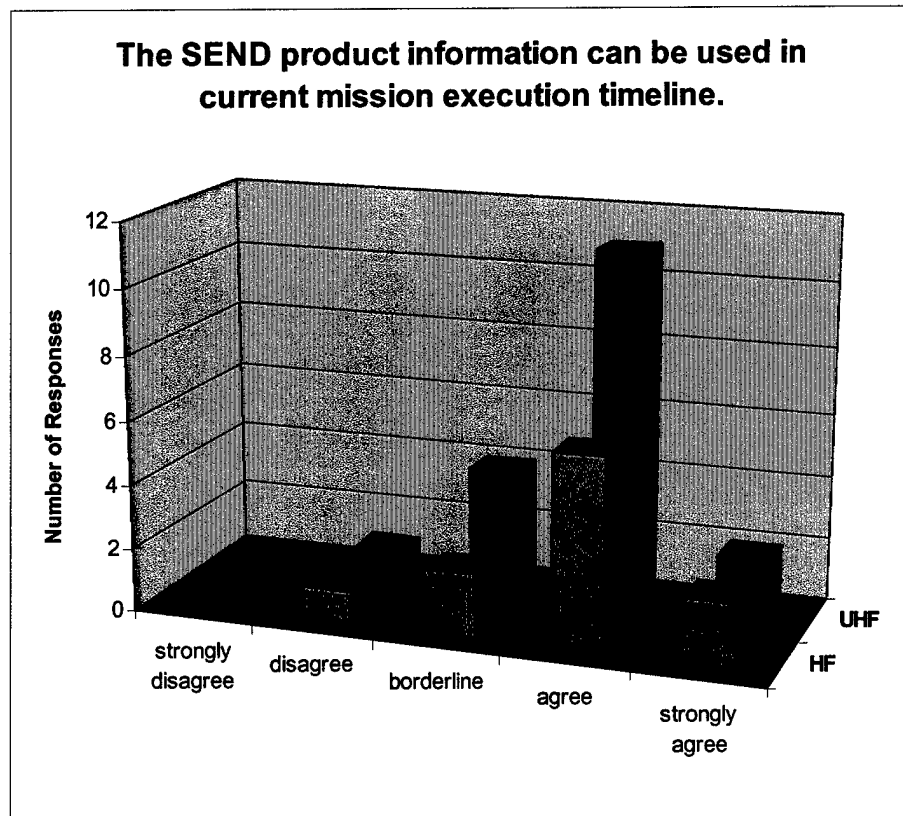


Figure 10. Potential user impressions of SEND value to mission execution.

"SEND product information changed or would change my current mission planning activities" was the third questionnaire statement. The histogram of the compiled results is shown in Figure 11.

The results presented in the histogram are somewhat similar to those associated with the first questionnaire statement (see Figure 9). As stated above, there seems to be little mission planning value of a tool currently incapable of long-range forecasting.

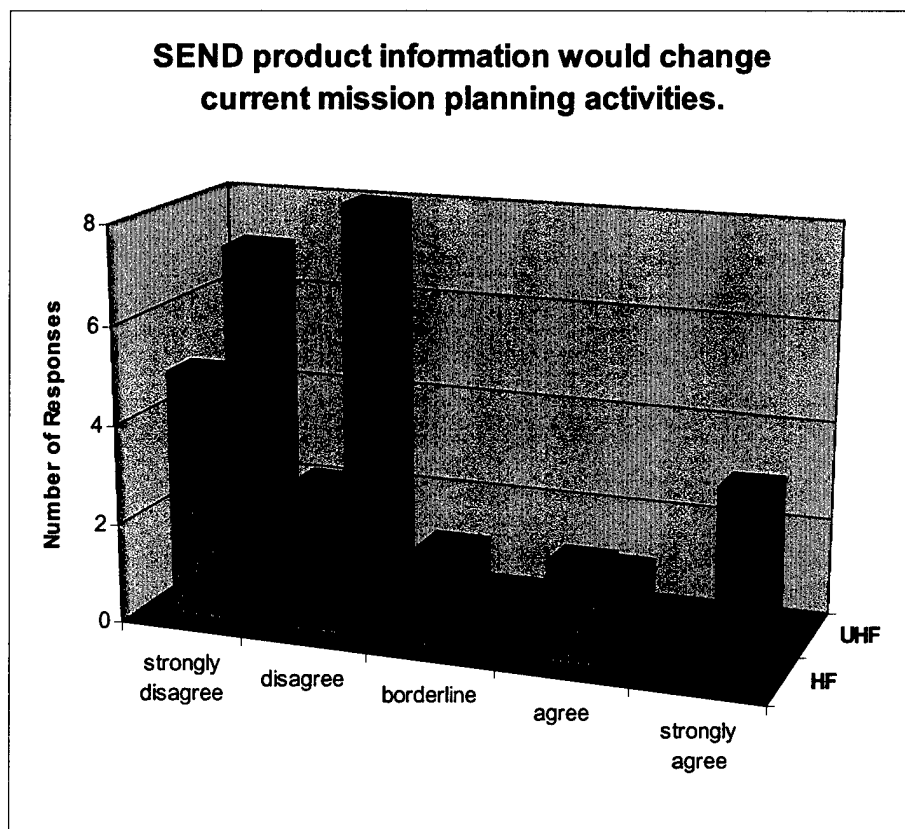


Figure 11. Potential user impressions of SEND effects on mission planning.

The histogram showing the compiled opinions on the statement, "SEND product information changed or would change my current mission execution activities," is shown in Figure 12.

As discussed previously, potential users agreed that SEND information would be useful during mission execution. Though not as enthusiastically, they also agreed that SEND information would change mission execution. This less enthusiastic response arose because most potential users did not have the opportunity to actually employ SEND product information during one of their missions, and so could not readily judge whether it indeed did change their execution activities.

The final two questionnaire histograms applicable to this objective compile responses to a simple question and a straightforward statement. The first of those, shown in

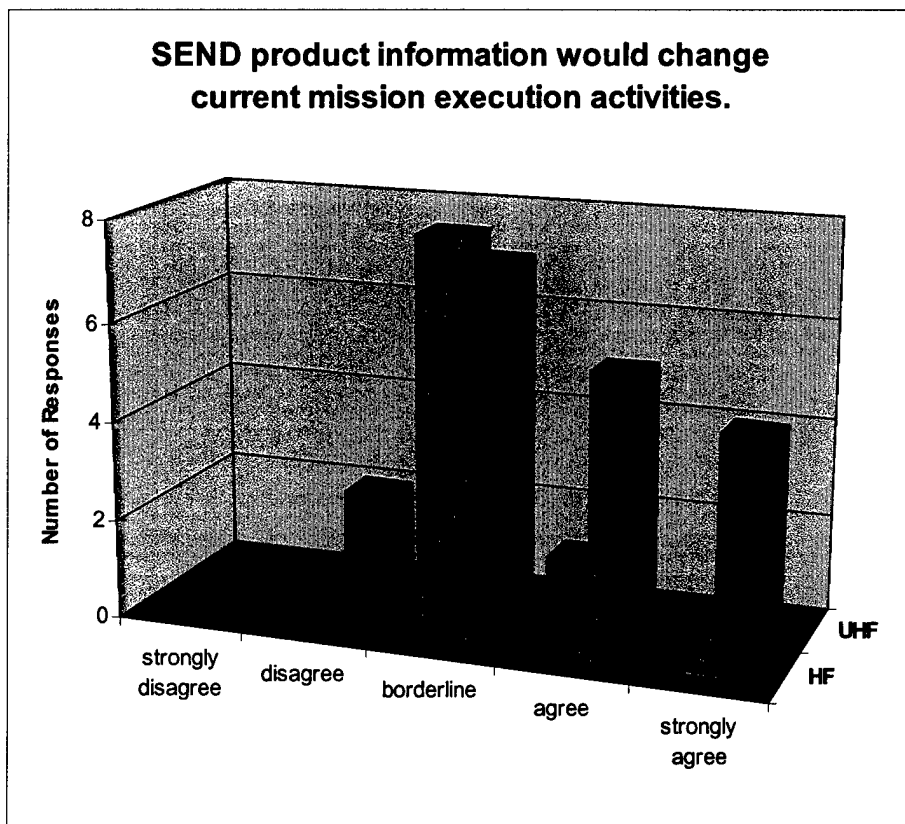


Figure 12. Potential user impressions of SEND effects on mission execution.

Figure 13, describes the yes-or-no responses to: "Do you think the SEND product information is useful?" Potential users unanimously agree that the HF Illumination maps were useful. Nearly 70% of potential users also agreed that the UHF SATCOM Outage map was useful. Those who did not feel the UHF SATCOM Outage map was useful cited two specific reasons for their belief: 1.) the UHF SATCOM system is only a backup communications method for some potential users, and 2.) some UHF SATCOM questionnaire respondents believed that the lack of a long-range forecasting capability made SEND not useful.

The last utility histogram (Figure 14) reflects whether users agree that the information provided on SEND products is mission essential. As can be seen on the histogram, there is no consensus among potential users on this statement.

### Do you think the SEND product information is useful?

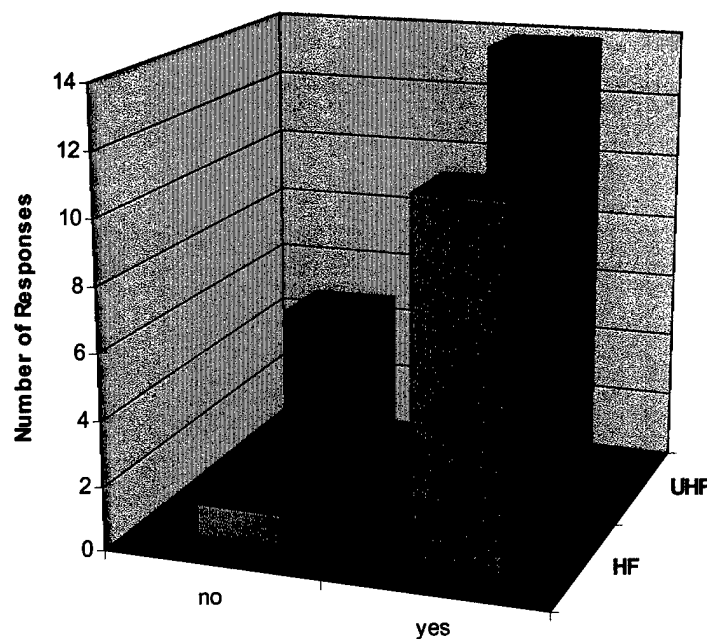


Figure 13. Potential user impressions of SEND utility.

### Access to SEND product information is mission essential.

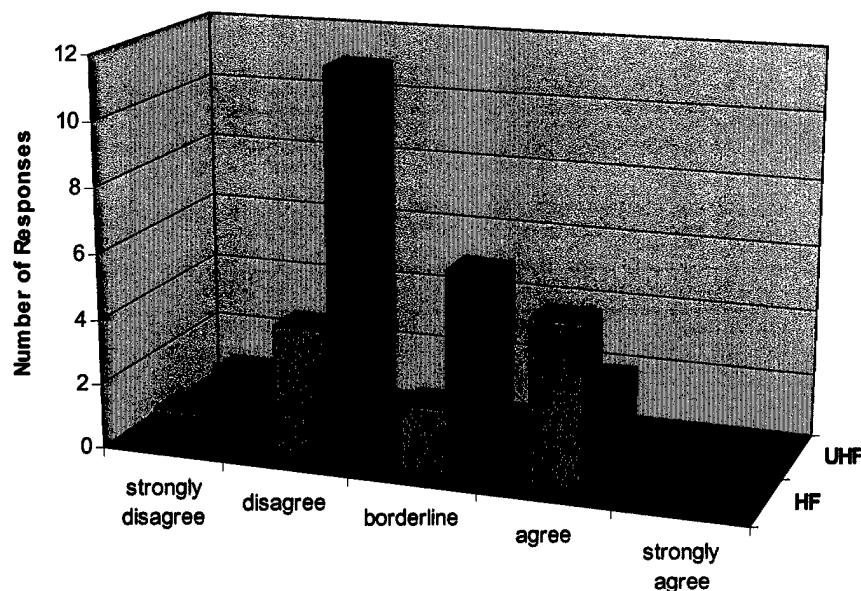


Figure 14. Potential user impressions of whether SEND information was mission essential.

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Seemingly, potential users find the SEND information useful, but they are not prepared to suggest that it is essential to mission success.

In addition to the results depicted on the histograms, potential users made numerous comments which demonstrate their belief in the military utility of the SEND system.

- ❑ *Not essential, but very helpful (from the Frequency Manager point of view).*
- ❑ *Not "essential", but very helpful in analysis.*
- ❑ *Nice to have, but not essential.*
- ❑ *HF not critical info, yet helpful.*
- ❑ *Communication is everything in Special Operations Force activities.*
- ❑ *Majority of communications problems is operator error - not space anomalies.*
- ❑ *Great tool. Good for use during link establishment and troubleshooting. Also can assist major communication stations in preventing outages.*
- ❑ *For Frequency Managers. More of a troubleshooting tool after the fact. Would be useful for commanders and tactical elements.*
- ❑ *A good tool for last second info with operational units. Not a Frequency Manager tool -- needs more forecasting capability.*
- ❑ *Useful for tactical ops and last second frequency selection (of frequencies allocated). Not useful for Frequency Manager planners other than troubleshooting.*
- ❑ *Too late for most Frequency Managers.*

### **Objective 2**

**Determine the ease with which new users can effectively operate the SEND system.**

Three questionnaire statements were used to examine the ease of use of the SEND space environment products. The first statement

applicable to this objective required the potential user to answer, "Understanding the SEND product was: ..." The allowable responses to this statement were: very difficult, difficult, borderline, somewhat easy, or very easy. The compiled opinions of the potential users are shown in Figure 15. Potential users generally agree that understanding the SEND product was not difficult.

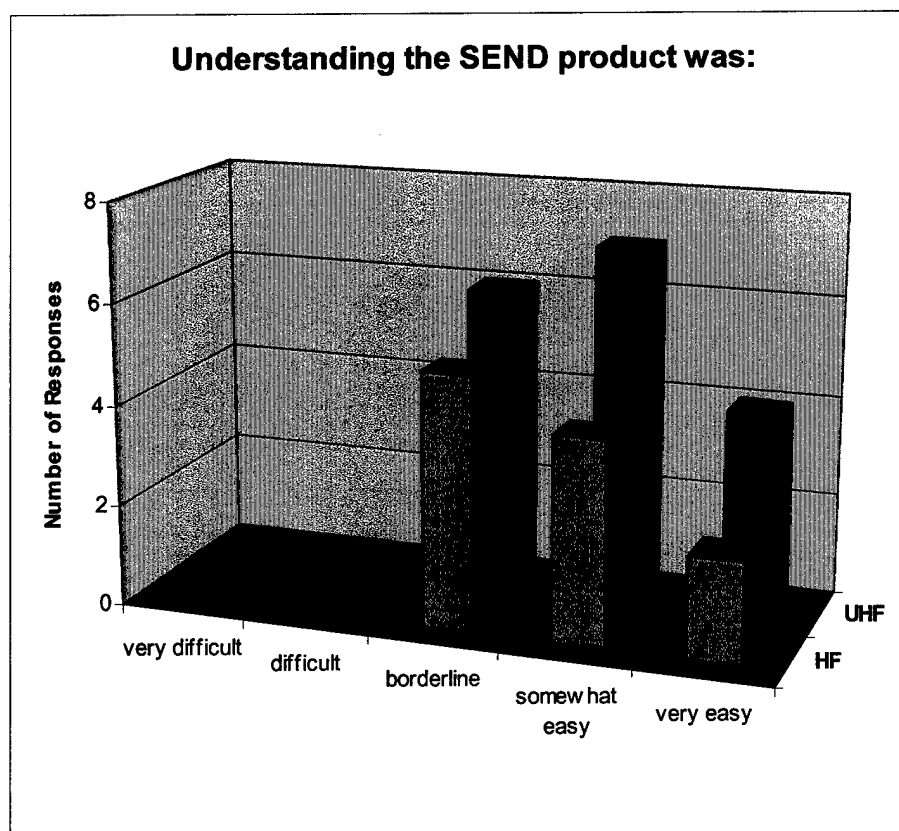


Figure 15. Potential user impressions of system understandability.

It was even easier for potential users to locate the time of map generation – a critical piece of information for users concerned with the validity of the products they are viewing. The compiled user impressions are included in Figure 16.

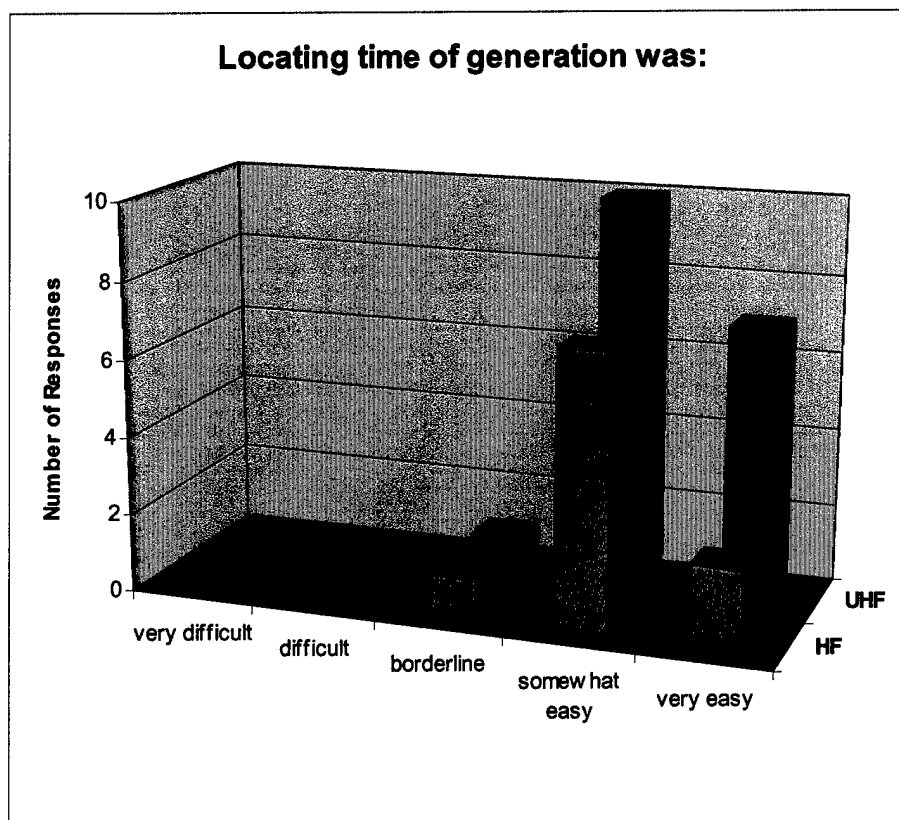


Figure 16. Potential user impressions on how easy it is to find the map generation time.



Finally, potential users were asked a simple overarching question: "Do you like the SEND product?" Respondents unanimously answered yes to this question, as shown in the Figure 17 histogram.

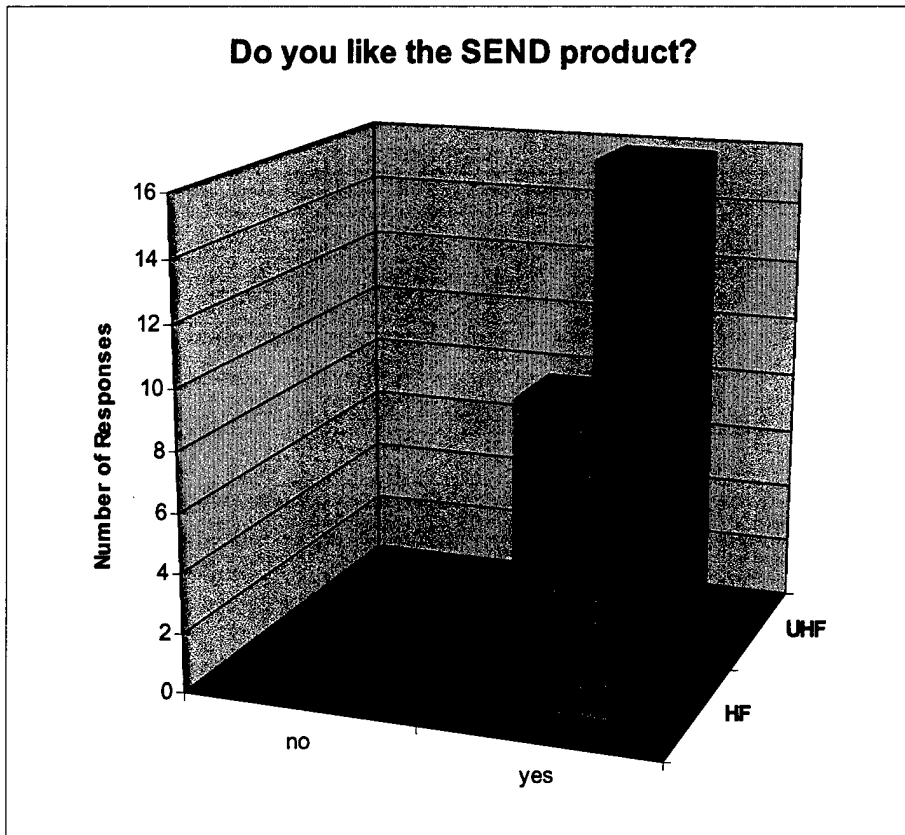


Figure 17. Potential user responses on whether they like SEND products.

Two ease-of-use comments were made suggesting improvements not in the web page presentation itself, but in the "help" documentation which accompanies each page.

- *With no place to find details, the HF beginner is liable to carry away a false or misleading impression of what he's seen.*
- *Suggest adding an "About Notional Scintillation Outage Maps" page. Include a discussion of the significance of the numbers presented on the map. Include what DISS and IMS are. Provide information on the probability of detection and false alarm rate.*

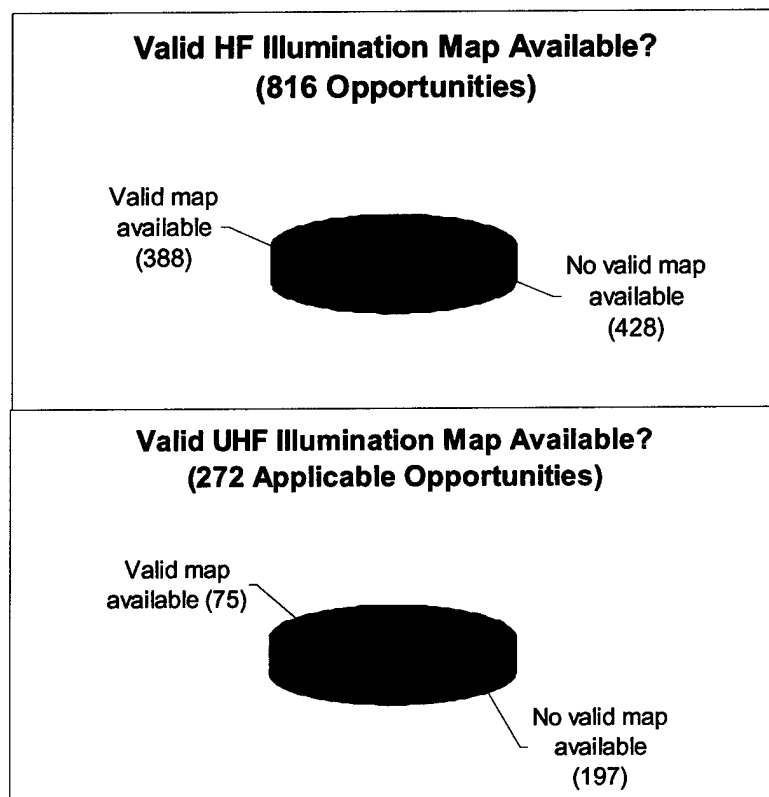
### **Objective 3**

**Determine the percentage of time SEND product information is placed onto the SIPRNET web page for global dissemination.**

SEND system performance with respect to this objective was determined objectively. Every thirty minutes during the demonstration, new HF Illumination and UHF SATCOM Outage maps were to be generated and placed onto the SEND SIPRNET web page archive. (This equates to 816 total map generation opportunities.) The number of times when the entire SEND transmission path was operational, resulting in generation of valid space environment products, was logged. The pie charts shown in Figure 18 present the percentage of the LMUA period when valid maps were available. (Since UHF SATCOM Outage maps would only represent scintillation between the hours of 2200Z and 0600Z, the number of total available UHF generation opportunities is lower than the total number of HF generation opportunities.)

Valid HF Illumination maps were available on the SIPRNET web page 388 times of the 816 opportunities (48%). Valid UHF SATCOM Outage maps were available 75 times of the 272 opportunities (28%).

As described in Appendix A, the reasons behind product unavailability were principally related to the MDS, and not to SEND. The pie charts in Figure 19 depict the availability of the SEND space environment products on the Internet web page. Since the products were not generated on the Internet before 11 April 1999, the number of generation opportunities is significantly less than on the SIPRNET web page. Figure 19 shows that 259 times of the 289 opportunities (90%) HF Illumination maps were available, and that 77 out of 98 times (79%) UHF SATCOM Outage maps were available. The percentage of time where valid space generation products were available would have been even higher if the down-time due to the pre-scheduled power outage on



*Figure 18. HF Illumination and UHF SATCOM Outage maps were available on the SIPRNET during only a portion of the LMUA.*

Ascension Island on 15 April 1999 would not have been counted as available map generation time.

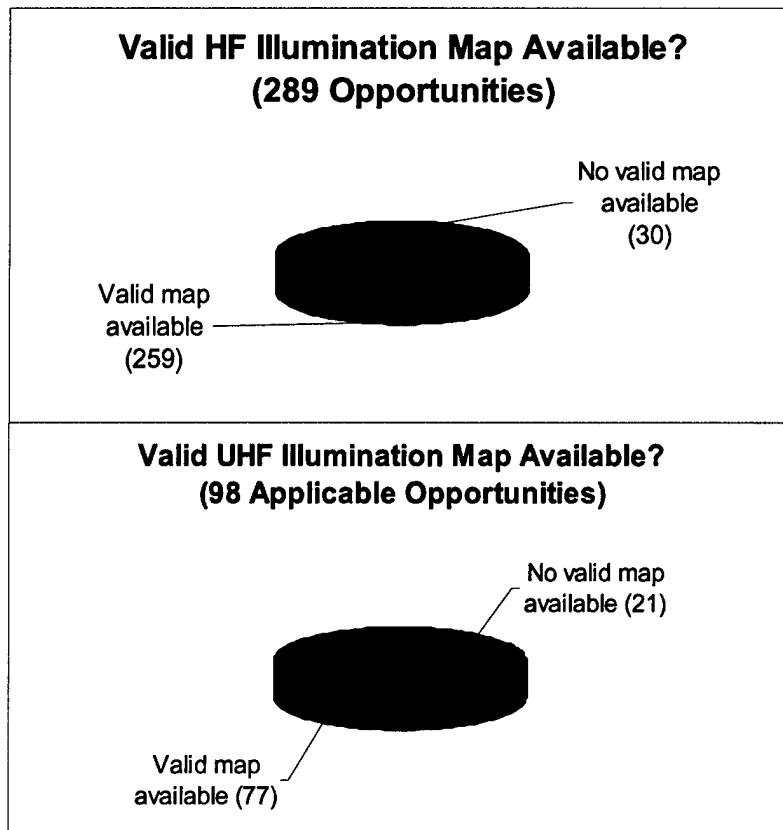


Figure 19. HF Illumination and UHF SATCOM Outage maps were available on the Internet much more often.

Because of classification issues, it will never be possible to completely ignore secure communications systems and to place UHF SATCOM Outage maps (that contain all of each map's appropriate information) on an open network like the Internet. Yet, it should also be assumed that the SIPRNET/MDS communications network to the 55<sup>th</sup> SWXS will probably never again be so fickle as it was during the LMUA demonstration period. So, the global dissemination metric assessing the percentage of time when space weather products are available is probably some number between the SIPRNET and Internet percentages outlined above.

#### **Objective 4**

**Determine the time required to transfer space environment information from the sensor field site to the SEND product display on the SIPRNET.**

The timeliness of SEND space environment products was determined objectively for the UHF SATCOM Outage maps. A "data age" metric was placed in the lower right corner of each outage map. This data age represented the latency from the end of a SCINDA data collection period to the generation of the outage map using that data set. This latency was internally measured by the SEND system.

Figure 20 presents that latency for all the maps placed on the Internet web page. The average latency from the end of data collection to the end of map generation was 16.5 minutes. The average latency for maps placed on the SIPRNET was 21.3 minutes.

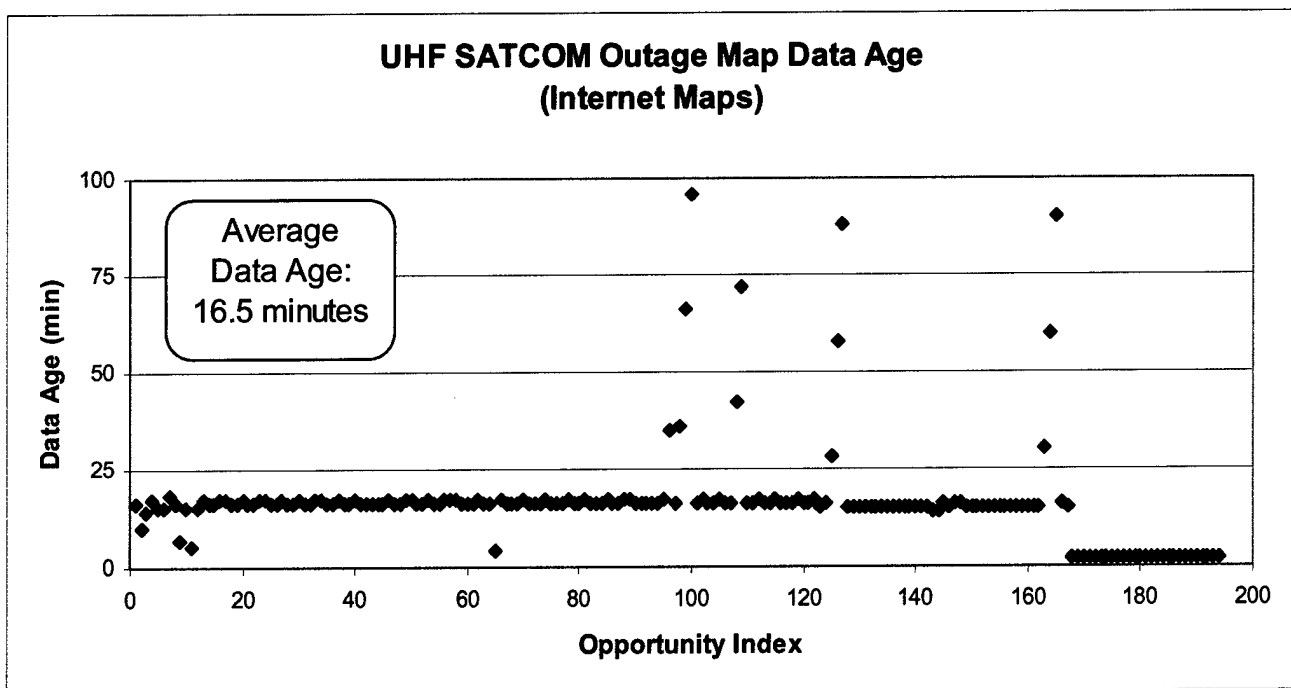


Figure 20. AFRL calculated that the latency from SCINDA data collection to Internet map generation was usually less than 20 minutes.

No objective timeliness evaluation was possible for the HF Illumination maps. The only timeliness metric available for those maps were the data status lights included on each map. The logic behind the red-yellow-green lights was a function of the most recent data set. If that set (from the DISS or the IMS) was less than one hour old, then the appropriate status light (DISS or IMS) would be green. If the set was more than one hour old, but less than two hours old, the status light would be yellow. If the set was more than two hours old, the light would be red.

During the period when the Internet web page was operational (not including the intentional power outage), the IMS status light was yellow only once. Ignoring the time when the DISS was disconnected for leave-behind activities, the DISS was always green.

#### **Objective 5**

**Determine the percentage of potential operational time during which the SEND system is operational.**

Independent data was not collected to determine the percentage operational time for the individual SEND system components. Performance with respect to this objective can, however, be estimated by analyzing the global dissemination data collected for

Objective 3. During the last week of the LMUA demonstration, the SEND system components generated Internet space environment HF Illumination maps 90% of the time; they generated UHF SATCOM Outage maps 79% of the time. Dismissing the pre-scheduled power outage and leave-behind activities – which should not be considered reflective of SEND component reliability – those numbers climb as follows:

- Valid HF Illumination maps were generated 286 of 289 opportunities (99%).
- Valid UHF SATCOM Outage maps were generated 60 of 64 opportunities (94%).

The performance presented does not paint a full picture of the percent operational time because, if the components had failed intermittently between map generation times, that would not appear in the data. Nonetheless, the percentage of maps generated reflects favorably upon the capabilities of the SEND system components.

One other issue worthy of discussion with respect to this objective is whether scintillation occurs enough to merit graphical presentation. The calendar shown in Figure 21 shows the nights during the LMUA when scintillation storms occurred. Though not consistent or persistent, some level of scintillation did indeed occur during 6 of the 18 LMUA demonstration nights.

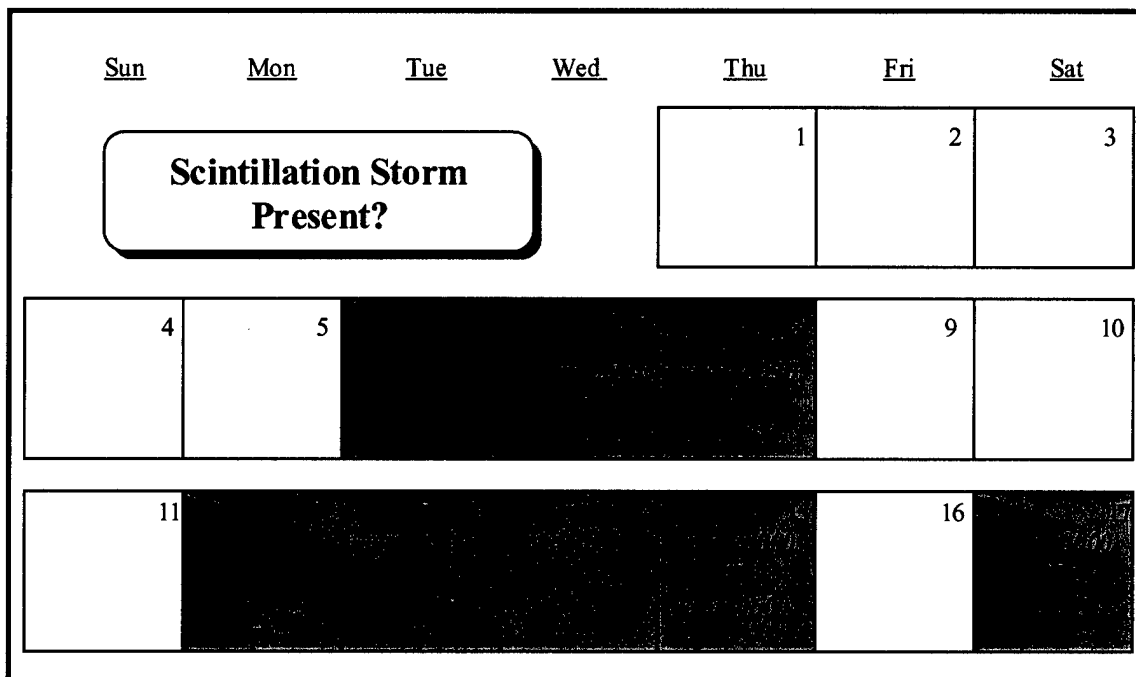


Figure 21. Scintillation did indeed occur during numerous LMUA nights.

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## APPENDIX A: TEST EVENT CHRONOLOGY

System preparations were completed at Ascension Island on 31 March 1999. At 0000Z, 1 April 1999, the SEND system began collecting ionospheric data and generating space environment products in support of the LMUA. The system continued to collect data and generate products in support of the demonstration until 2330Z, 17 April 1999. This subsection describes anomalies which precluded the successful collection of some data during various demonstration periods.

### 1 April 1999

**HF Illumination:** From 0000Z until 0030Z, the maps generated by the PRISM and HF Raytrace contained incorrect valid map times. Instead of using new data as it arrived, the SEND system used the 2100Z, 31 March 1999 set repeatedly to generate maps until 0030Z. The repetition occurred again from 1300Z until 1930Z, where the 1300Z data set was used to generate 15 identical maps. After 1930Z, this situation did not occur again during the LMUA.

### 3 April 1999

**UHF SATCOM:** Starting at 1130Z, the 55<sup>th</sup> SWXS MDS – which collects incoming data from a worldwide network of ground sites, including 16 DISS and 5 IMS instruments – was shut down in response to a real-world Information Condition (INFOCON) Bravo. Since the MDS was a single-point failure component of the SEND data transmission path, shutting it down effectively shut down the ability of SEND to generate any new UHF SATCOM Outage maps.

**HF Illumination:** The MDS shutdown similarly hindered HF Illumination map generation. Because the data status lights on the map only present the time since the arrival of the most recent data set, the lack of new maps (due to the MDS drop-off) was not noticed until 1300Z.

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4 April 1999

**UHF SATCOM and**

**HF Illumination:** The MDS was still off due to the INFOCON Bravo; no maps were generated.

5 April 1999

**UHF SATCOM and**

**HF Illumination:** The MDS was still off due to the INFOCON Bravo; no maps were generated.

6 April 1999

**UHF SATCOM and**

**HF Illumination:** The MDS was switched back on to allow transmission of SEND data from Ascension Island back to Schriever AFB at 1630Z.

The batch processes ("queues") responsible for processing sensor data through the MDS worked momentarily at 1630Z, but by 1900Z, they had failed, again cutting off sensor data from the PRISM. The batch queues were not restarted until 1530Z, 7 April 1999.

8 April 1999

**UHF SATCOM and**

**HF Illumination:** A fiber-optic line at Schriever AFB used to forward data to the MDS broke at 2000Z. Since data could not get to the MDS, the PRISM did not generate any maps.

9 - 11 April 1999

**UHF SATCOM and**

**HF Illumination:** The fiber-optic line was not repaired; no maps were generated these days.

Based upon the unavailability of presentable SEND data on the SIPRNET web page (as described above), AFSB enlisted AFRL to generate sanitized (unclassified) UHF SATCOM Outage and HF Illumination maps at Hanscom AFB and place them onto an Internet web page. The first products were available on that page at 2330Z, 11 April 1999.



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12 April 1999

**UHF SATCOM and**

**HF Illumination:** The fiber-optic line was repaired at 1900Z, allowing transmission of SEND data from Ascension Island and placement of space environment products onto the SIPRNET web page.

13 April 1999

**UHF SATCOM and**

**HF Illumination:** A requirement to support a periodic computer inspection forced the shutdown of the MDS from 1300Z until 1900Z. Since the data was still being collected at Ascension, this shutdown only prevented SIPRNET map generation; products were still available on the Internet web page.

15 April 1999

**HF Illumination:** A pre-scheduled power outage on Ascension Island shut down the SEND system from 0630Z until 2030Z. Neither Internet nor SIPRNET products were available during that period.

Since the Air Force Space Command had requested that the DISS be left behind at Ascension Island, the DISS was moved during the power outage and was not used again in support of the LMUA. Throughout the rest of the demonstration, therefore, HF Illumination maps were generated on both the Internet and SIPRNET web pages using the IMS only.

**UHF SATCOM:** In addition to the power outage, the SCINDA had to be disconnected to permit removal of the DISS. Neither Internet nor SIPRNET products were available during the entire day.

16 April 1999

**HF Illumination:** Only IMS-induced maps were presented on the Internet and SIPRNET web pages.

**UHF SATCOM:** SCINDA was still disconnected. Neither Internet nor SIPRNET products were available during the entire day.

17 April 1999

**HF Illumination:** Only IMS-produced maps were presented on the Internet and SIPRNET web pages.

**UHF SATCOM:** SCINDA was re-connected at 1800Z. Both Internet and SIPRNET web page products were available from 1800Z until the end of the demonstration.

Figures A-1 and A-2 graphically summarize the chronology information provided in this subsection. The colors in each calendar's square depict the following conditions: red – no products available on SIPRNET during that day; yellow – at least one product available on SIPRNET that day; and green – all scheduled products available on SIPRNET that day.

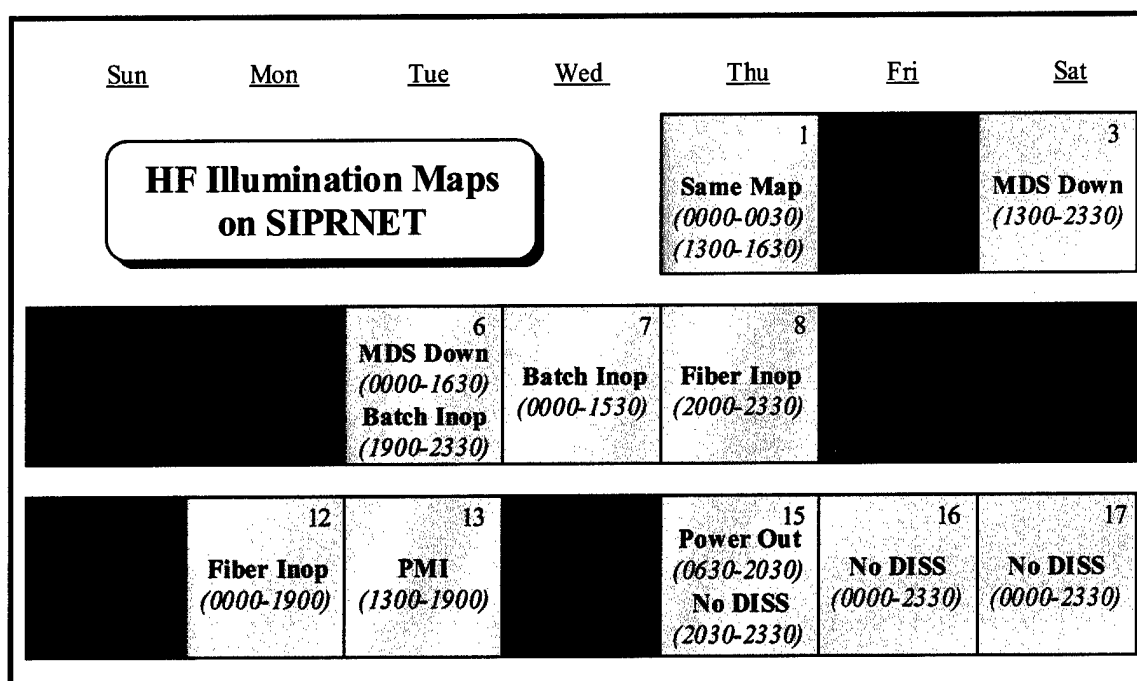


Figure A-1. HF Illumination products were only available during a portion of the LMUA.

<u>Sun</u>	<u>Mon</u>	<u>Tue</u>	<u>Wed</u>	<u>Thu</u>	<u>Fri</u>	<u>Sat</u>
<div> <b>UHF SATCOM Maps on SIPRNET</b> </div>					2 <b>Firewall</b> (1600-2100)	3 <b>MDS Down</b> (1130-2330)
		6 <b>MDS Down</b> (0000-1630) <b>Batch Inop</b> (1900-2330)	7 <b>Batch Inop</b> (0000-1530)	8 <b>Fiber Inop</b> (2000-2330)		
	12 <b>Fiber Inop</b> (0000-1900)	13 <b>PMI</b> (1300-1900)		15 <b>Power Out</b> (0630-2030) <b>Disconnect</b> (2030-2330)		17 <b>Disconnect</b> (0000-1800)

Figure A-2. UHF SATCOM products were only available during a portion of the LMUA.

In addition to monitoring product status, Det 1 conducted interviews and solicited inputs via e-mail from the potential user population. Approximately 135 e-mail requests were transmitted; a single questionnaire was returned.

Approximately 30 personal interviews were conducted; all interviews were conducted in Hawaii. Personnel were interviewed from the organizations listed below.

- Commander in Chief, Pacific Command (CINCPAC)
- Commander in Chief, Pacific Fleet
- US Marine Forces, Pacific
- Headquarters, Pacific Air Forces
- US Special Operations Command, Pacific
- Joint Task Force, Full Accounting
- 7th Fleet
- 3rd Special Operations Squadron
- Naval Computer and Telecommunications Area Master Station, Pacific
- Joint Spectrum Center
- CINCPAC Cruise Missile Support Activities

The interviewer used notes taken during those personal interviews to complete questionnaires for each interviewee. Of the 38 questionnaire responses included in the significant results section, 27 were completed using this method.

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## APPENDIX B: LIST OF ACRONYMS

AFSB	Air Force Space Battlelab
CINCPAC	Commander in Chief, Pacific Command
CINCs	Commanders in Chief
Det 1	Air Force Operational Test & Evaluation Center, Detachment 1
DISS	Digital Ionospheric Sounding System
DMSASESPO	Defense Meteorological Satellite and Space Environment System Program Office
GHz	Gigahertz
GPS	Global Positioning Satellite
HF	High Frequency
INFOCON	Information Condition
KBI	Kenney Battlelab Initiative
LMUA	Limited Military Utility Assessment
MDS	Meteorological Dissemination System
MUA	Military Utility Assessment
NIPRNET	Nonclassified Internet Protocol Router Network
PRISM	Parameterized Real-time Ionospheric Specification Model
SCINDA	Scintillation Network Decision Aid
SEND	Space Environment Network Display
SIPRNET	Secret Internet Protocol Router Network
SNR	Signal-to-noise ratio
SWA-AOR	Southwest Asia Area of Responsibility
SWXS	Space Weather Squadron
UHF SATCOM	Ultra-High Frequency Satellite Communication

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